A Publication of the International Council on Systems Engineering

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INCOSE

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INSIGHT

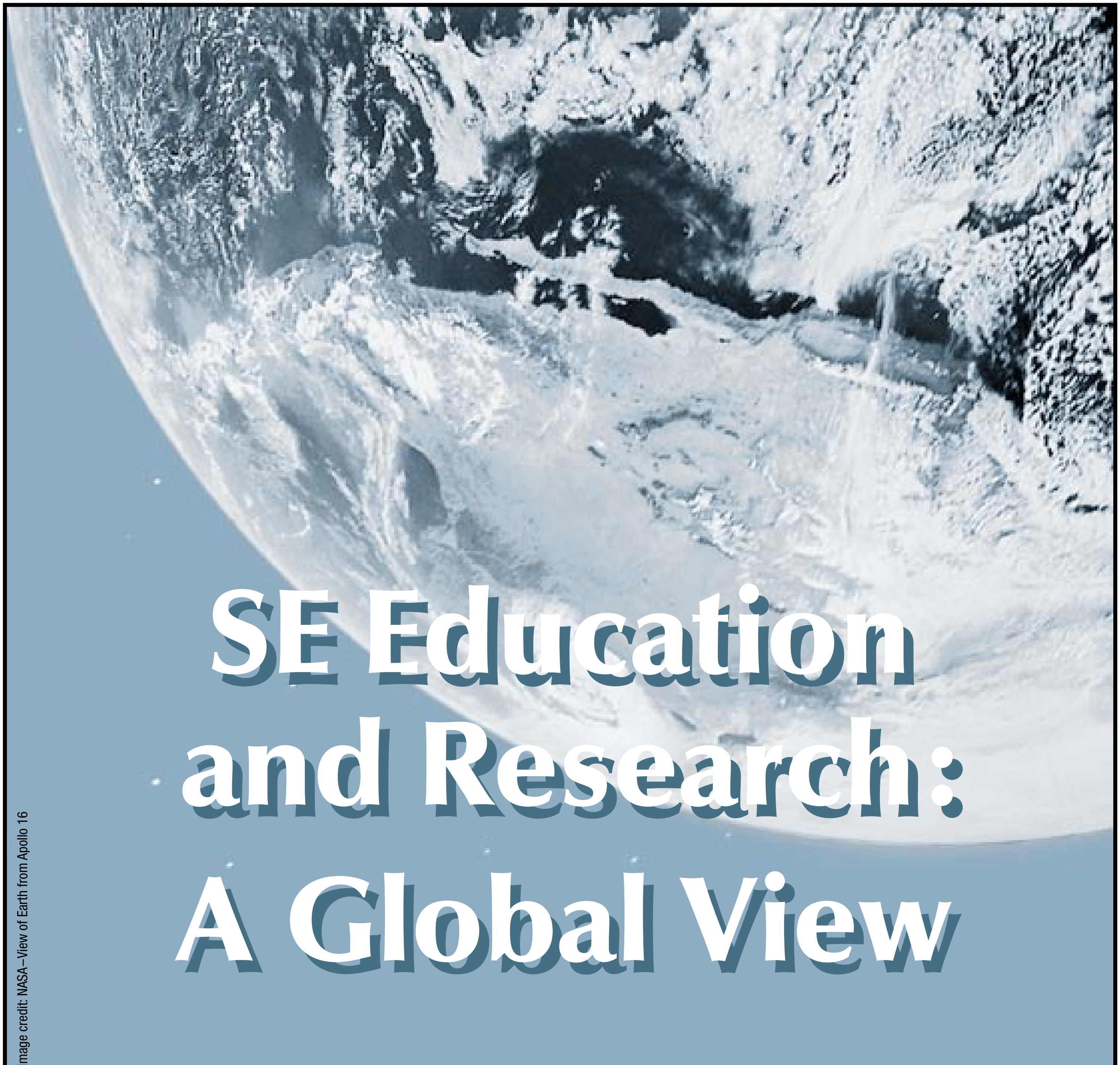

Image credit: NASA–View of Earth from Apollo 16

INCOSE

INSIGHT

A PUBLICATION OF THE INTERNATIONAL COUNCIL OF SYSTEMS ENGINEERING

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Copy Editors: Lori Pajerek, Shirley Bishop

From the Editor

SE Education & Research: A Global View

Global View. INCOSE stands at the threshold of a singular opportunity. Our members from around the globe agree that the elements of Systems Engineering (SE) are already embedded in many currently taught engineering courses. The problem is SE as a *discipline* is not taught very many places. Yet there is growing worldwide recognition of the value of systems thinking in maturing and managing complex endeavors. This recognition is creating new demand for engineers and managers who are capable of working in and leading multi-disciplined technical teams. INCOSE's challenges relative to education and research are to become the recognized international authority on what substance should be taught to aspiring systems engineers, and what research should be pursued to advance the state of the art in systems engineering.

INCOSE's Education and Research Technical Committee members believe there is a set of SE core courses that need to be taught to all engineers. However, a number of factors combine to make the replacement of existing courses in other engineering disciplines with SE courses a very hard sell. These factors include: cultural differences, difficulties in adding courses to an already jammed curriculum, competing and conflicting claims from professional organizations, questions about the legitimacy and value of SE as a discipline, and resistance to change. Further complicating our task is the fact that the whole of SE deals with abstract thought about core concepts and their relationships. Much as the Roman engineer and architect Vitruvius was able to establish the relationship of art and science in architecture, INCOSE must champion the concept that SE is the art, and science, of harmonizing content across disparate disciplines with process.

Convincing the world's educational community to embrace SE as a *discipline* is a formidable objective. Without the creation of more departments of systems engineering at educational institutions, progress in replacing the art of SE with science will be slow. Without the research that would be done at those same educational institutions, the growth in the scientific content of systems engineering will be sluggish.

Prerequisite to achieving the desired international acceptance is the need to transcend cultural differences. This issue of ***INSIGHT*** is dedicated to the proposition that our members, by working together for a common cause, are making a difference. I hope each of you will conclude, after reading the contributed articles, that we are beginning to overcome current constraints and persuading people there is value in teaching systems engineering.

Professor Heinz Stoewer's lead article describes the graduate and international postgraduate systems engineering programs he fostered at the Delft University of Technology in the Netherlands. Based on the increasing demand for his students and student response to these programs, Heinz has done an excellent job of defining SE programs to meet a market need. Another case study in implementing an SE program is provided by Dr. Herman Migliore. Herm's program is slated to start in the fall of 1999 at Portland State University in Oregon.

Three articles from Australian members direct our attention to other important issues. Dr. Louis Doukas describes a program he helped implement for teaching

continued on following page

President's Corner

Ken Ptack, ptack_ken@prc.com

As I start my Presidency, I see INCOSE continuing to grow and be recognized as the systems engineering focal point for the world. At the 1999 International Workshop, we had the greatest international participation of any of our workshops to date, approximately 20%. This year's symposium focuses on "Sharing the Future." The number of papers that were submitted for consideration by the 1999 Symposium Committee was more than double that of previous years. I helped review papers from each of the focus areas and they were all very good. The quality of submissions is increasing each year, making the selection process very critical. As the world shrinks and budgets get smaller, it is imperative that we share our technical knowledge with our global neighbors in order to do things smarter. I know that you will gain more than you expect in Brighton, U.K., the site for this year's symposium.

The International Workshop in January 1998 was a busy and productive one. The first day started briskly, for those staying at the hotel, with a cold shower. This woke everyone up and gave us the energy to work hard in our groups. We made great progress on our products in our Technical Working Groups. Those that were there and those that contributed electronically, comprise the development teams that make the INCOSE products what they are. We ended the first day by relaxing with the premier broadcast of Dilbert. During the Workshop, I announced the procedure for the electronic down load of the Systems Engineering Capability Model, EIA/IS 731. This is one of the collaborative efforts that INCOSE worked as a joint venture with the Electronic Industrial Alliance G47 Committee. This is another example of how INCOSE products will help improve our future as an organization.

Our membership continues to grow both individually and on the Corporate Advisory Board. Based on our increased membership, we have new chapters being formed throughout the world. I challenge each of you to continue this trend by informing your friends and co-workers about the benefits that you gain from your membership. Encourage them to join INCOSE and your chapter, or start a new chapter in your local area.

My focus this year is to continue the advances we have made in member support services. We will continue our excellent ***INSIGHT*** under the supervision of our Managing Editor, Valerie Gundrum. Our Quarterly Journal, led by Chief Editor, Andy Sage, is being published and distributed on a regular basis with outstanding articles of interest to us all. Our Web page is being updated on a regular basis with pertinent information posted as soon as it is available. We have access to a collaborative tool that will allow us to communicate better between working groups and committees. We are making progress in providing better tools and processes to conduct our daily business. All of these "communications" should help us progress into the twenty-first century.

During the closing session of the International Workshop, I told a story about a couple that rode down in the hotel elevator with me. His wife said that her husband had been a systems engineer years ago but now was not. I asked him what he did now and he said, "I am doing the same thing that I did years ago but it isn't called systems engineering." The name of what we do is not important, but the work being performed is. Again, I challenge each of you to continue to develop usable products and provide the person-to-person interface of INCOSE to your friends and co-workers. Publish articles in your company paper, post flyers about your local chapter meetings, and encourage your local chapter to work on one of the technical products as a team.

You are the voice and heart of INCOSE, and with your help we will continue to grow and be successful. I look forward to seeing you at the 1999 symposium in Brighton.

Kenneth R Ptack

From the Editor

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system engineering in Vietnam. Dr. Stephen Cook of the University of South Australia gives a status report on what is being done in his country to build SE research partnerships and train people to relieve a critical shortage of systems engineers. Dr. Peter Sydenham, the Educational Measurement Working Group founder and chair, voices a concern that industry and academe are not communicating with each other when it comes to systems engineering. He suggests INCOSE become more pro-active in creating a dialogue with organizations that should be hiring systems engineers.

Professor John Boardman from De Monfort University in Leicester, England has contributed a provocative article, based on his research, challenging us to rethink conventional notions about systems engineering. Dr. Abd-El-Kader Sahraoui from the University of Toulouse in France tells us how system engineering could be the vehicle for improving engineering education. Tom Strandberg with Syntell in Stockholm, Sweden completes our theme with his observations on the growing recognition of the need for systems engineering education and training in Sweden.

The level of international interest in systems engineering may pleasantly surprise you. It certainly delighted me.

Phil Brown
Theme Editor

End-to-End Systems Engineering: The Key to Successful Products and Services

Prof. Heinz Stoewer, HeinzStoewer@compuserve.com

Introduction. Successful products in any market segment must be user and service oriented. Success depends on a balanced package of technical performance, affordable cost, timely availability, and the needed service.

This applies to space based products as much as to any others. It is crucial for the open commercial market but it applies also to many government-sponsored projects. With public space expenditures declining and new opportunities opening in the communications, information systems, navigation and remote sensing/geo information fields, space industry is reorienting its business focus on a global scale.

Delft University of Technology's Aerospace Engineering Faculty has long ago recognized some of these trends and has reoriented its structure and educational curriculum. In particular, in our new international postgraduate Master of Space Systems Engineering Programme, SpaceTech aims to educate young professionals to "grow from just being good engineers to become systems engineers with an instinct for business." [1]

Today's space scenario – a competitive challenge.

The winds of change. After 35 years of steady growth with primary focus on launcher and satellite technology –resulting in highly capable, reliable, but often rather costly space missions – the space community is re-engineering its basic processes in a most fundamental way. The changing international competition and the major shift in space priorities have led to a paradigm shift regarding cost, time to market, and the need for providing end-to-end, turnkey services.

Increasing share of commercial space. Commercial space is becoming the healthiest part of the industry, with new applications and low Earth-orbit satellite constellations in telecommunications information, navigation, positioning and remote sensing systems. The supporting ground segments and associated service elements are the first links. The related downstream Earth segments and service sectors increase the economic importance of these systems by a full order of magnitude.

Service – the new dimension for the Space industry. As space technology finds its way into the fundamental processes of global economics and industries, for example, in the information, energy, transportation, or environment protection fields, the space segment often becomes only an enabling tool to enter the enormous secondary but lucrative "terrestrial" service sectors. Space industry, in alliance with other industries, can realize attractive market growth rates if the chance to invest and to move into this direction is seized.

The changing space industry environment. The changes in the industry affect the total environment. They are felt on strategic, business, and technological levels — these three levels being interactive and interdependent. Figure 1 summarizes some of the more relevant tendencies. Good systems engineering needs to be responsive to all of these in order to generate market-oriented, economically viable products and services.

Consequences for space education. Figure 2 aims to summarize some of the consequences for space education. The effects can be felt, or need to be implemented, at the strategic, business and technological levels. Adjustments need to be made in interaction with the customers of the educational products. These trends force, for example, attention to life-long learning, and they require increased attention to marketing and business topics, also for engineers. Amongst others they should include sufficient hands-on possibilities to allow engineers to gain or deepen confidence not only with paper and tools, but also with hardware, preferably also on the system level.

The European Forum on space education in Toulouse, France. In October

Figure 1 **The Space Business is Changing**

• Strategic environment	• scientific exploration and applications/commercial become separate developments • public vs industry investments affect roles of parties • industry integration forced by global competition • development focus replaced by life-cycle emphasis
• Business environment	• markets developing rapidly • seamless space and terrestrial information system! • breakdown of classical barriers between: — telecom, Earth observation, meteo & navigation — civil & defense • service sector opportunities • launchers retain crucial role: cost! • cost, return on investment, time to market dominate
•Technology environment	• rapid engineering knowledge base update cycle • mass and power reductions affect systems designs • constellation capabilities and orbital autonomy • integrated simulation/design approaches become competitivity drivers • ground network elements on PC basis change ops centers

Figure 2 **Consequences for Space Education**

- **Strategic enviroment**
  — anticipate trends and upgrade curricula in cooperation with users of educational products (industry, research establishments, agencies)
  — foster industrial and international cooperations through internships, cooperative Masters/PhD theses (incl. language skills and multicultural experiences)
  — create awareness of need for life-long learning (incl. postgraduate courses)
- **Business environment**
  — upgrade engineering curricula to include intros to marketing/business topics
  — improve understanding of “non-space” issues, e.g. interaction with terrestrial systems and products
  — strengthen knowledge base on processes, e.g. cost engineering, development vs production aspects, life cycle engineering
- **Technology environment**
  — foster multi-disciplinary design interaction and advanced tools
  — improve focus on new technologies, e.g. payload vs bus, *end-to-end* information systems, constellations, micro/nano and service technologies
  — include hard- and software *hands-on* vs theoritical experiences

1998, the Institute of Space Sciences and Applications of Toulouse (ISSAT) organized a Forum on Space Education in Europe. This forum brought together industry, agencies and universities from twelve European countries. Its objectives were to:

- assess the current situation as regards education and training
- identify the needs of manufacturers, users and space agencies
- envisage actions to meet the challenges of tomorrow

The chairman of the Forum, the President of ISSAT, Mr. Remondière, noted:

- The space sector involves complex, integrated systems often implementing the very latest technology. It is also multidisciplinary, and projects are frequently based on international cooperation.
- Twenty years or so ago, training focused in particular on science and technology. Today training has to take in account market needs, though scientific disciplines still undoubtedly attract many students.

The forum revealed a strong determination of its participants to move ahead. The space industry is inevitably developing towards a European industry, not by a juxtaposition of national strengths, but by a manufacturing capability able to withstand world competition. Space education and training must therefore take this into account. Ventures must be European if we wish to gain a good footing on a world level. Over the two days of the forum, the European dimension was greatly emphasized in the papers of representatives from a variety of countries.

Undergraduate and Graduate Space Education at the Delft Aerospace Faculty.
We at Delft pay a lot of attention to understanding the trends and needs of the industry and the aerospace business worldwide. Our aim is to anticipate and adapt our educational programs accordingly.

The multi-disciplinary approach. While general engineering, physics, mathematics and other topics are the dominant subjects in the first two years of aerospace engineering education in Delft (figure 3), the multidisciplinary topics, which include systems engineering, gain dominance from the third year onward. Several months of international industrial internships and individual thesis work are part of the fourth and fifth year curriculum. This is also the time when students choose to specialize in aeronautics or in space. The faculty has a range of facilities supporting “hands-on” student work. The latest addition is a “clean-room,” a space laboratory where students work with a real space system, consisting of a flight status satellite, user terminal, ground station and check out equipment (figure 4).

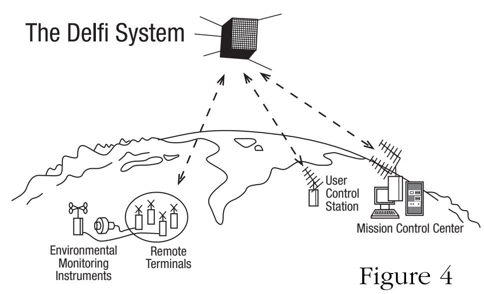


Figure 4

The faculty has recently changed its organizational structure to emphasize the horizontal systems engineering and integration forces in a matrix organization (figure 5).

In summary, good systems engineering skills and end-to-end systems thinking, together with sensitivity for and knowledge of the programmatic and managerial environment, lead to viable market-oriented designs and end products. The combination of systems engineering and business engineering, including project management tools, and the focused enhancement of personal skills, characterize the modern aerospace engineer, which we in Delft aim to educate. While our graduate program focuses upon

Figure 3 **General outline of course subjects**

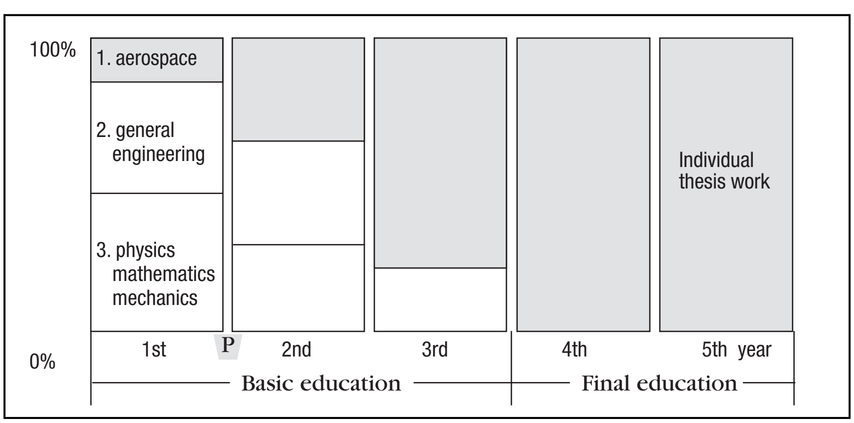
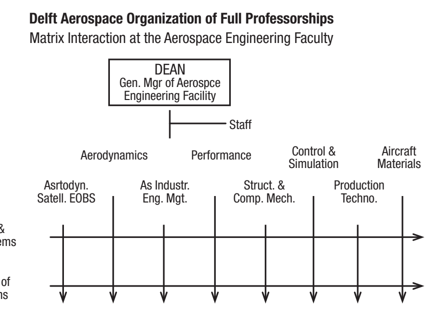


Figure 5


multi-disciplinary technical and communication skills, with some sensitivity and knowledge on the business side, our postgraduate program, called SpaceTech, aims at producing true end-to-end systems engineers.

SpaceTech: our "Master of Space Systems Engineering" international postgraduate program

The culmination of the Delft space systems approach is our postgraduate educational SE program. The program takes young professionals, who have worked some years after having acquired their initial Masters Degree in any engineering discipline, into our very intensive end-to-end systems engineering educational program. We have developed, in cooperation with industry, agencies and research establishments, the international SpaceTech Program, leading to the unique degree of "Master of Space Systems Engineering."

Our international Curriculum Committee from some seven countries, including the United States, has defined a program with a strong focus on market-oriented and cost-conscious end-to-end systems engineering (figure 6).

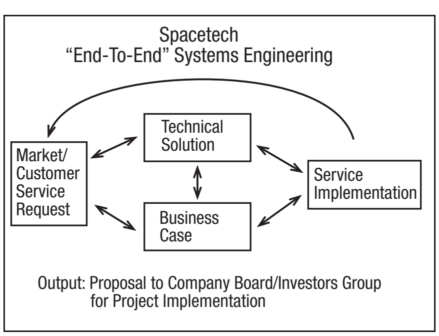


Figure 6

Program structure and contents. The SpaceTech program is generally directed towards complex systems, with a space segment being just one node of this total system. It covers a system end-to-end, that is from the user/customer requirements or (soft) market needs through the systems architecting and design, to delivery of the end-products service to the user/customer. The program is made up of four major interactive and time-phased blocks (figure 7).

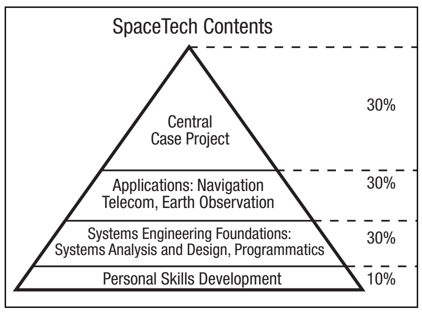


Figure 7

The building blocks: Systems engineering foundations. This block lays the foundations for advanced systems engineering. Its principal objective is to have participants (who are more or less specialists in the one or another engineering discipline) think "end-to-end," that is, to learn to deal with market or customer requirements and all its relevant technical and related programmatic facets. This block covers:

- Systems analysis
- System design
- Program management/business engineering

The foundations-block provides education on systems engineering tools and principle system equations, including PC-based spreadsheets for major systems parameters and associated trade-offs. It also provides the basics in the marketing, business and management fields, and hence lays the groundwork for system architecting and end-to-end solutions with a focus on life cycle cost (figure 8) and return on investment.

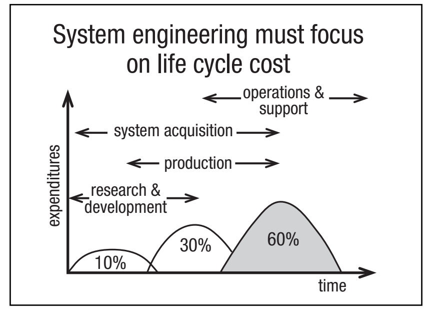


Figure 8

Applications. This block deepens the technical and business knowledge of the participants and enters into key fields of space applications, including the associated economic and commercial issues. It reviews the state of the art in these fields, presents the latest system and technical developments and market trends, and deals with the technology, engineering, service, and management challenges ahead. Together with the systems engineering foundations it provides the insights that allow the Central Case Project to be conducted in a realistic and up-to-date environment.

Central Case Project. The knowledge gained in the previous blocks is exercised against a practical market oriented case project. Participants define a space mission from beginning to end. They identify the market/user needs, do the necessary systems analyses and select the system constituents and its service elements, and they perform trade-offs with business and "return of investment" constraints/targets. This is done in iteration with the initial market analysis.

They exercise the systems engineering tools and methods in a real life, in an iterative manner, and finish writing a draft proposal for a company board or a group of investors. This encompasses the necessary technical documentation and scopes the development, manufacturing and operations as well as the business, marketing and project management plans.

Personal skills development. Each of the above takes about 30% of the study time and effort. The remaining time is devoted to personal skills development, where participants learn to interact in multi-cultural teams, improve communication and presentation skills—all skills which systems engineers need to be successful in real life project teams.

Industry guidance and advice. The program is backed by an Honorary Council under the chairmanship of the Minister of Education, Culture and Science of The Netherlands. It includes the Rector Magnificus of Delft University of Technology, the Chairmen of Agencies and Industry. It is guided by an Advisory Board comprised of key executives from throughout the space-related community. The Curriculum Committee directing the day to day program is composed of leading experts in systems and project-management, all with extensive hands-on experience in an international environment.

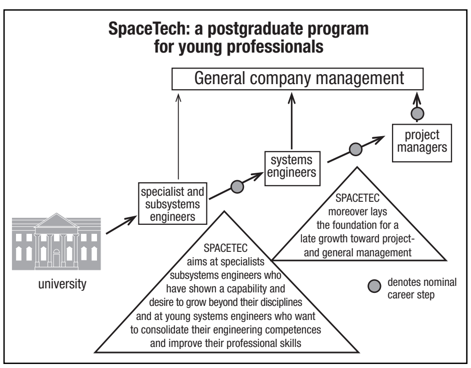


Figure 9

SpaceTech target groups. SpaceTech aims at specialists and subsystems engineers with a Master degree in any applicable engineering discipline, or in physics, as well as at young systems engineers who want to consolidate their engineering and programmatic competencies and improve their systems engineering skills (figure 9). Prerequisite for admission to the program is that they have five years of experience in engineering and have proven to be good engineers. It has consequently drawn participants with high career potential in its three years of existence. In fact more than half of its 36 participants to date have already realized career advancement. Their

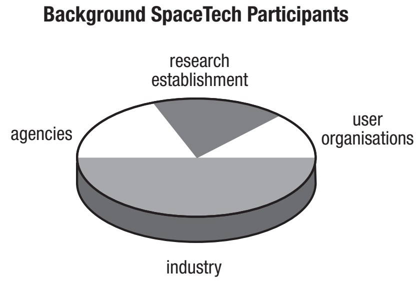


Figure 10

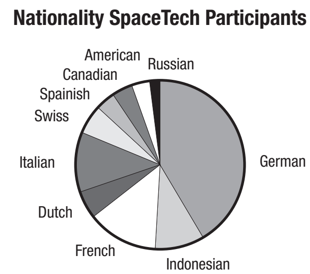


Figure 11

background and nationalities are shown in figures 10 and 11.

The program is structured around five intensive on-campus periods of two weeks each during the time frame of some eight to nine months (figure 12).

This tailored method of teaching postgraduate Master's students was developed several years ago by Delft University of Technology and has had good success. In addition to the on-campus periods, it entails distance learning during the off-periods. During these off-periods, participants will complete assignments and work on the team project via the Internet with fellow participants and instructors. Time invested during these off-periods is about the same as the on-campus hours. One or two of the on-campus periods are conducted at major European aerospace centers, such as the one in Toulouse.

SpaceTech is part of a network of university, industry, agency and

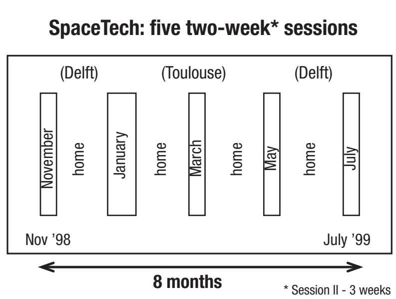


Figure 12

research center partners, and involves several of Delft University of Technology's staff, led by its ABET evaluated Aerospace Engineering Faculty. It is certified by an independent Certification Committee for postgraduate education under the chairmanship of the Rector Magnificus.

Conclusions

Space engineering is maturing to become a normal industrial sector with a continued strong growth potential and a much stronger commercial and total systems orientation. We in Delft have recognized this trend, and have adjusted our educational programs and structure during the last few years.

Aerospace systems engineering has been substantially boosted and culminates in the unique international postgraduate Master's of Space Systems Engineering degree program. Systems engineering for other terrestrial industrial applications is also taught to varying degrees in other faculties in Delft, qualifying Delft University of Technology as one of the leading educational competence centers in this growing field of multidisciplinary engineering interaction.

Postscript

People are divided into 3 groups:

1. *Those who make things happen*
2. *Those who watch things happen*
3. *Those who wonder what happened*

System Engineers do not belong to groups 2 and 3 !

Professor Dipl.-Ing. Heinz Stoewer, *is a Professor for Space Systems Engineering and Programme Director of SpaceTech, of the Delft University of Technology, The Netherlands.*

1 Statement by the former chairman of the SpaceTech Honorary Council, Minister Dr. Ritzen at the occasion of the opening of the second SpaceTech year, September 1997.

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Starting A Systems Engineering Program

Dr. Herman Migliore, herm@eas.pdx.edu

Introduction. Over the last two years, Systems Engineering at Portland State University (PSU) has progressed from a tentative idea to an approved degree program with funded development activities. This progress is due to contributions from several sources: PSU, state government, regional industries, and from systems engineers around the world. The following details are presented not as a formula for similar programs, but as an acknowledgement of contributors and as a summary of work-in-progress.

Measurements are continuously being made to discern the program's validity, popularity, impact on other PSU programs, and acceptance by the established systems engineering (SE) community. For the most part, this development effort is governed by the SE approach, but some decisions were made in response to immediate opportunities. In any case, an important philosophy of the planning process has been, as the saying goes, thinking globally, but acting locally.

Locally Active

About two years ago, the School of Engineering came under the leadership of Dean Bob Dryden. Dean Dryden's previous position was head of the Industrial and Systems Engineering Department at Virginia Institute of Technology. Bob's close colleagues include Wolt Fabrycky and Ben Blanchard. Dean Dryden's experience in such a successful program reinforced his view of Systems Engineering as a focus for interdisciplinary projects and as a positive influence on all engineering programs. As a consequence, SE was organized at the School rather than departmental level.

The School of Engineering & Applied Science (SEAS) has offered senior design project courses as part of its curricula, all of which participate in a university wide, interdisciplinary capstone requirement. The Director for the SE program was selected based on his experience with design education, interdisciplinary projects, and successful working relationships with existing engineering faculty and local industry. Although the SEAS program will focus on post-baccalaureate education, undergraduate courses will benefit from the formal processes, attention to interface issues and consideration of the total life cycle.

Oregon's state universities are organized under the Oregon University System (OUS), a centralized Chancellor's office. OUS has encouraged Oregon universities to propose innovative programs, responsive to state needs. The SEAS Master of Engineering in Systems Engineering was approved under this favorable climate. Special state funds directed by OUS for engineering education has resulted in the development of a SE Approach Web course and funding of three other SE Web courses. These courses will capitalize on the vast potential for distance learning over the Internet.

PSU's mission encourages partnerships with local industry at all possible levels, including applied research, undergraduate and graduate courses, certificate programs and short courses. Such an environment nurtures a faculty responsive to industries' needs and thereby receptive to the initiation of a SE program. At PSU, SE can grow in any of several directions, as opportunities might dictate.

Local industry demands for engineering education and professional training is very strong due to the complexity of their products and multi-disciplined nature of their workforce, mostly in electronics hardware design, software applications and wafer production. The enormous growth of high-tech firms in the Portland "Silicon Forest" area is another contributing factor. SE as a discipline may not be familiar to them, but the requirement to rapidly develop complex hardware and software products for a world market using interdisciplinary teams is all too familiar. SE process and skills are being presented to local industry as an aid in product development and presented in a format that is easily supports a dynamic learning environment.

Global Thinking

There is a wealth of SE resources from which to draw. The PSU SE program enjoys the close collaboration of the great leaders in the field, including Brian Mar, Wolt Fabrycky, and Ben Blanchard. These professionals are providing short courses that will allow PSU to announce its SE plans, conduct needs assessments, and develop a base of satisfied customers. Portland's proximity to Seattle provides convenient interaction with Boeing and its systems engineers and several have made suggestions for the program.

INCOSE members are keen to promote university involvement. INCOSE tutorials, primers and certificate courses have much to offer PSU in its short course development. PSU's SE Director participates in INCOSE's Education Measurements Working Group, giving first-hand experience at SE expectations for education and training activities. The INCOSE SE Center of Excellence (SECOE) offers PSU the possibility of joining an established collaboration of SE programs.

From the onset, PSU's SE program has focused on working engineers and applied scientists. The Web provides a means to meet the time constraints of working professionals. Courses can be offered asynchronously to students located anywhere on the Web. Resources for teaching may be obtained from the Web, and Web instruction continues to be cheaper, more flexible and of improving quality. With careful design, Web instruction adds a dimensionality to learning that is seldom possible in a traditional classroom setting.

Implementation

PSU will continue to offer short courses as a School effort and in partnership with the Oregon Center for Advanced Technology Education, an OUS distance learning facility. Highly qualified instructors who are experts in their fields teach these courses.

PSU's Master of Engineering in Systems Engineering has been approved with a planned launch date in Fall 1999. The degree is geared to the working engineer in several respects: 1) significant component of practicum, 2) core courses on the Web, and 3) transferability of electives. About one third of the program are elective courses allowing the student to specialize in a domain, but electives will be tied to SE skills and concepts by SE seminars.

The first core course is SE Approach, a Web course offered Spring 1999. Text material, part of a multimedia format, will be complimented with weekly on-line chat room discussions and an active learning approach to instruction. The Web development courseware use WebCT software, supported by PSU's Office of Information Technology. During the Summer 1999, existing modeling and operations research courses will be modified as part of Web core, and development of a software-hardware integration course will begin, all of which will become part of the Web core course curriculum.

Summary

SE concepts have proven their value in defense systems and the development and manufacture of complex commercial hardware and software products. Younger urban universities have the flexibility, agility and directive to quickly respond to the dynamic needs of industry. The Web is revolutionizing approaches to and delivery of distance learning. These factors, along with help from a few SE Emeriti, are imparting a unique character to the Systems Engineering program at Portland State University, www.eas.pdx.edu/systems/.

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Teaching Systems Engineering in Vietnam

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Last July in Hanoi, eighteen students were awarded Master's degrees in Systems Engineering (SE). This is believed to be the first engineering Master's degree conferred in Vietnam by a foreign university. The SE program producing these graduates was developed and taught by Royal Melbourne Institute of Technology (RMIT) University in Melbourne, Australia, in collaboration with the Vietnam National University. This new SE initiative in Vietnam is part of the university's long term strategy to internationalize all their educational programs. RMIT's international programs evolved from development assistance programs started in the 1950s. The first offshore programs began around 1986. Last year, RMIT enrolled over 5300 students offshore. Onshore international students numbered over 6,000. Success is attributed to developing partnering relationships with over 190 institutions. A majority of these are with Asian neighbors in countries such as China, Indonesia, Malaysia, Singapore, Thailand and Vietnam.

Faculty in RMIT's school of engineering developed the SE program for Vietnam. The engineering faculty comprises more than 520 academic and support staff spread over 18 departments. They cater to some 9,000 students enrolled in trade, paraprofessional, undergraduate and postgraduate courses.

Recognition of the program's value in promoting Australia came last year with the Austrade Australia Export Award and the Governor of State of Victoria Export Award. The Australian Trade Commission award was for "outstanding export achievement in the fields of education services, facilities, expertise and curriculum development…." The award is open to providers who earn foreign exchange from business activities in both Australia and overseas markets.

RMIT's relationship with Vietnam National University began in 1994 with the establishment of the Joint Centre for Systems Development in Hanoi. The Systems Development Centre sponsors a range of activities, such as training programs for Ford employees and student recruitment. In 1997 the two universities jointly set up the International Co-operation House. The purpose of this facility is to host seminars and educational programs conducted by both institutions.

The Master's of Engineering in SE

is the university's first degree program to be taught in Vietnam. The program was brought to fruition with the help of both the Vietnam National University in Hanoi and the Australian government. Success was in large part due to transcending cultural differences, providing a program of use to the local populace, and emphasizing the need to co-operate.

Success in teaching the principles of SE to students from a less developed country is attributed to the extensive use of case studies. Course work emphasized how to apply SE knowledge to real-life problems faced by the Vietnamese community today. The value of working in multi-discipline teams was also taught. Using real life local experiences stimulated student involvement and interest. Case studies in working in teams gave students a deeper appreciation of the value of SE in developing solutions.

Positive feedback from the first 18 graduates has already generated a lot of interest in Vietnam. A training course was developed and given to professional practitioners from across the country. Thirty-one new students started the second program this past November. In addition, several research projects have also been started. Ten Master's of Engineering (Systems Engineering) research programs are nearing completion. SE research is being done in the areas of information technology, infrastructure development, water distribution systems, logistics, and activities focusing on program or project management.

At the first graduation ceremony, Professor David Beanland (Vice-Chancellor of RMIT's International Division) pronounced the event a significant milestone for RMIT University. He noted it marked the fruition an innovative program breaking new ground in RMIT's partnership with Vietnam National University. He completed his remarks by saying, "The University is delighted to welcome eighteen new members to the RMIT Alumni."

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Systems Engineering Activities between Australian Academia and Industry

Stephen Cook, Stephen.C.Cook@unisa.edu.au

The Australian Systems Engineering Scene. The practice of systems engineering in Defence and Aerospace industries in Australia is well established. It is based on U.S. Department of Defense concepts combined with a noticeable European influence, and features a high degree of project-specific process tailoring. Systems engineering practice reflects the largely overseas ownership of Australian industry, but also the type of systems work performed: often no higher than sub-system level with solutions comprising a high proportion of non-developmental items.

In addition to the factors that are causing the explosion of activity in systems engineering practice development that we observe through INCOSE, Australian organizations are also beset by other challenges. The first is the increasing appreciation within the Australian Department of Defence that technology per se does not provide military advantage: rather that this is achieved through systems that comprise defense materiel, and well-trained, well-led personnel nurtured in a solid military culture and supported by suitable doctrine. Consequently, there is an increasing emphasis on operations and systems research within Australian Defence research laboratories and a growing awareness of the potential synergies to be gained from integrating systems of systems. This has led to a growing interest in high-level architectures and the enhancement of acquisition and other processes that support their creation. These trends are also being paralleled in civilian areas, most noticeably infrastructure and information system developments.

These contemporary realities have created a critical shortage of systems thinkers and systems engineers, and consequently a burgeoning need for training in these areas.

Postgraduate Education Options. It is a requirement in Australia that a master's degree comprise no less than five years of full-time university education. Thus, as all of our engineering degrees are four years, a master's degree can be obtained in as little as twelve months, though 18 months to two years is typical. Two variants exist, one is comprised of mostly coursework with a modest research thesis, and the second is a master's by research that requires no coursework (for suitably trained candidates), and takes at least two years full-time. Graduate certificates and diplomas also exist for six months' and twelve months' coursework study respectively. An Australian PhD follows the British model; it is based solely on research, takes a notional three years (typically over four) and the thesis is forwarded to international experts for examination.

A consequence of the rise in popularity of university education has been the dismantling of free tertiary education and the progressive re-introduction of fees. Students now pay for roughly one third of their undergraduate education costs ($20,000 for engineering) and as of last year, full fees for a master's degree by coursework (around $15,000). Not surprisingly, the numbers in coursework-based higher degrees have plummeted.

To my knowledge there are only two coursework master's programs in systems engineering in Australia, and a third program is evolving. The Royal Melbourne Institute of Technology (RMIT) has offered a Master of Engineering in Systems Engineering for over a decade. The University of Technology Sydney (UTS) has taught their Master of Engineering

Management, which has a strong systems engineering component, for a similar length of time. The University of South Australia (UniSA) has been teaching electronic systems and test and evaluation master's programs for many years, and started postgraduate coursework in systems engineering last year. Course approval documents are currently being prepared for a new Master of Engineering (Systems Engineering) that will be delivered in weeklong modules. This is a bold initiative given the current climate.

The situation for research degrees is altogether brighter. It is normal to obtain a fee exemption scholarship (certainly every candidate does at the University of South Australia where I work), and many scholarships exist that pay useful tax-free stipends to Australian citizens that have achieved excellent academic results.

Research Concentrations

The Systems Engineering and Evaluation Centre (SEEC) at the UniSA is the only funded university research centre in Australia dedicated to systems engineering. Research interests lie in high-level defence systems, particularly command and control systems; defence processes for strategic planning, capability development, and systems acquisition and test and evaluation; and industrial systems engineering. The Centre is growing rapidly from its current modest base of six paid staff and twenty research students. RMIT is known for its research in the applications of systems principles to infrastructure engineering and logistics. The Australian Defence Force Academy has been working on the application of system dynamics and soft systems concepts to operations-research-type problems. UTS has been active in systems engineering management and front end processes. The INCOSE Region VI Systems Engineering conference, SE98, held in November last year, also saw evidence of research interest in systems engineering from The Australian National University and The University of Wollongong.

Mechanisms for Enabling Research Relationships Between Universities and Industry

Australian universities interact with industry using a wide range of commercial options. External activities are growing steadily in response to government policies and the desire on the part of universities to remain relevant to the needs of industry. Consultancies and contract research are conducted in much the same way as everywhere. Another very effective way to interact is to encourage employed engineers to undertake research degrees part-time. This permits individuals to pursue their career in conjunction with their academic goals. Importantly, it also provides the university with a realistic laboratory environment. The more enlightened attitude to part-time research degrees that has emerged in Australian academia in recent years has encouraged many mid-career engineers to consider undertaking higher degrees by research. The results have been very encouraging, with the research outputs displaying the enhanced maturity of the candidates.

Larger scale collaboration with industry falls under the general heading of sponsored research. This can be facilitated by direct financial contributions or through the assistance of competitive Australian Research Council grants. These grants, known as Strategic Partnerships with Industry–Research and Training (SPIRT), provide a stipend for a PhD student and some travel money. The industry partner is required to provide a similar level of funding which enables the university to dedicate staff and resources to the project. Competition for these grants is strong from all areas of academic endeavor. Selection is based on the quality of the proposal and the Principal Investigator's track record. The later tends to favor entrenched disciplines; however, SEEC is currently in possession of four of these grants spread over three industry partners.

Direct sponsorship of university departments or research centres is less usual in Australia than in many countries. Collaborative sponsorships tend to be modest but nonetheless extremely valuable as they provide teaching relief for academic staff and funds for research-only staff, both of which greatly enhance research capability. The only sizeable collaborative program in systems engineering with Australian universities is that between the Defence Science and Technology Organisation (the Australian Government joint defence research laboratory) and SEEC in the area of high-level military systems and systems of systems.

Mechanisms exist to fund major research centres of national importance. These require a substantial critical mass of researchers, say 50, and participation from several universities and companies. Providing the growth in systems engineering research and postgraduate teaching is maintained, a Co-operative Research Centre in Systems Engineering may become a reality in a few years.

Systems Engineering Practitioners Need Academic Support

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Introduction. It is recognized that academia is not providing sufficient support for organizations practicing Systems Engineering. This article considers why this is needed, what is impeding improvement, and suggests ideas for resolving the problem.

The "cradle to grave" phases of major technical programs are characterized by:

- Conceptual investigation after expression of need
- Integration sub-system solutions
- Detailed engineering design for a delivered system
- Manufacture and commissioning
- First operational life
- Upgrades and life extension
- Removal from service and disposal.

Overarching all phases is a need for technical knowledge of how to engineer and manage the systems total life cycle. The detailed engineering design and manufacture phases today enjoy considerable university following. This widespread support has built over the years academic sites around the world. This contrasts sharply with the interest in studying the remaining life cycle issues. For the purposes of this article, this is referred to here as Whole Life Sys--tems Engineering (WLSE). There are pockets of expertise, but they work largely in isolation from each other and as sub-critical groups.

Why is this so? Why do the technologies for building and managing complex systems have so little academic support? This article uses two contrasting, fictitious industry situations to illustrate the differences in available university support. This helps identify the factors that are impeding progress in supporting WLSE.

Mature Academic Support

Ecotel Corporation is a fictional mobile phone network company. It is losing market share to an alternative provider, and management recognizes the need to expand their network size and capacity to improve their competitive position. They know their closest competitor's operations are closely tuned to optimum conditions and that a real edge is needed to restore their fortunes.

Staff have some good ideas on how to proceed but need research to test the soundness of their ideas. They instinctively look to a telecommunications research unit for advice, analysis and alternative solutions. This research unit is at a nearby university. That unit will have 50 or more top-flight researchers who know where the leading edge of theory and practice is for this type of network system. The research unit will have support tools, including a network simulator, on which to run trial solutions. It will provide the needed help provided it has resources to conduct the investigation properly.

Ecotel Corp. understands the nature of research, and that it will take time to find answers. They appreciate that competitors also must cope with similar delays. They appreciate that use of a mature research unit will limit the length of the delay. Also, they can legally obtain information that the chosen research unit is sound and that it has the latest knowledge. Additionally, Ecotel Corp. has staff working in the unit who can set up the work without delay and be assured that research will relate to their need.

It is clear to Ecotel Corp. senior management that they must employ deep scholarly thinking and practices to improve their competitive position. Intuition alone will not produce the need value-adding advances.

This rather optimal generalization represents the kind of support available to industries in the telecommunications sector. The stakeholders of the industry generally support academic units as part of their own long-term support structure. Many industrial sectors enjoy this kind of scenario, but not the WLSE sector.

Situation inside the Systems House

Syseng, Inc., also a fictional company, has hit a crisis. One of their large programs has failed to meet a major milestone. A management review concludes there are serious engineering shortfalls that will take a lot of time to resolve.

The program manager recognizes the need to get help—but from where? He assembles a group of company experts. They all have different solutions based on their individual experience. They do not spend time researching the basis of their solution, so no one knows if their innovations will produce the desired results. A recovery plan is developed without any clear understanding of the risks involved in the plan.

Unlike the Ecotel Corp. case, management is unlikely to consider using a WLSE academic unit for several sound reasons:

- On previous occasions they have gone to detailed engineering design based university groups for help and been disappointed with outcomes. This is not surprising since those groups are not focussed on WLSE needs and are unable to stretch their knowledge base to produce SE solutions.
- Few academic activities specialize in WLSE. Lack of awareness of the needs of companies like Syseng, Inc. has hindered universities from building up mature activities.
- Inadequate long-term connections exist with suitable academic groups so the Syseng, Inc. staff has little appreciation of where to start looking or what to look for.

- Fear that details of Syseng, Inc.'s "crown jewels" may get passed onto competitors inhibits communication with outside organizations, especially a university with its open attitudes.

The net result is that seeking assistance from universities is considered a waste of time and money. Thus campus support does not mature. The Catch 22 situation exists.

While this vignette does not apply to all organizations with SE problems, it does highlight the major differences in those industry sectors having research support and the SE sector, which does not have research support.

Why does this situation exist?
Reasons for the lack of support for WLSE appear to be:

- This sector of industry does not value the role universities could play beyond providing vocational education.
- Faculty members need strong and sound incentives to shift their career directions to support WLSE. For this to happen there is need to grow robust WLSE units in universities. Critically needed are personnel with long-term WLSE aspirations who are already at the influential, or leadership, level. The pressures in place that influence academics to remain within established career path should not be underestimated.
- Insufficient demand for academic activity discourages faculty members from moving into this area.
- Inadequate recognition of SE as a discipline results in emergent WLSE campus start-ups becoming lost to the heavy influence of SE subspecialties, such as control, industrial, and software systems.
- Industry and academia do not interface adequately at a sufficient number of university sites.
- Academia is still coming to terms with the shift toward applied (versus pure) research and the changing drivers of present day demand.
- Government grant support bodies are unsure of where WLSE fits into their incentive mechanisms. The debate ranges between WLSE being supported by its own industry entirely, or by it being given targeted encouragement via granting mechanisms, as is normal for important industry sectors.
- Many for-profit SE organizations require bottom line justifications from potential campus support that cannot be met. Campus research is best suited for medium to long term solutions. Other industries recognize that the development of its university support pays off in the long term.

Conclusions
At present a few dedicated university, and other research, staff are leading the battle to improve academic WLSE support. University support may well emerge eventually if industry and government leave it up to them. It will, however, be a slow emergence because university work mostly follows funded fashions. It is also hard to prepare sound submissions for research grants in this situation. It is up to the benefactors of sound academic support to assist this need. It is up to industry and government to step in.

INCOSE activity identifies closely with the WLSE need. Some ideas for INCOSE to consider, as an enabling agency, are:

- Recognize that stakeholders must define their needs so universities can direct resources toward finding solutions.
- Lobby government funding agencies to support SE research.
- Fund scholarships and key strategic academic posts from its corporate membership.
- Partially support minor projects over many universities to raise SE awareness.
- Continue to provide forums bringing together university, government and industry to discuss what can be done to better integrate and develop the university support base for the WLSE sector.
- Provide evidence to stakeholders of the value of having strong, well-defined, SE research programs in the university sector.

Peter Sydenham is a member of Education and Research Technical Committee.

If Systems Engineering is the system, what are the parts and what are the relationships?

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When folk think about the word *system,* especially if they are systems engineers, they imagine something physical and maybe complex, like an aircraft or a missile. Maybe they think of a system as something that commands and controls the firing of a missile from an aircraft. The latter system has lots of people in it, people at work with a mission. This kind of system has been called a "human activity system," and some folk have even attempted to model these, in terms of processes, for example.

So it would seem that there exists a number of different types of systems, some of the more imaginative ones being INCOSE Symposia, or the documents that advertise these kinds of events. But what if the system was systems engineering itself? What does this system look like, using for example the lens "body of knowledge," which is only one such lens through which we might view this particular system?

One thing we know, or think we know, about any system is that it has parts, and there are relationships that exist between those parts. Hence the title of this article. Some might suggest that these parts are the engineering disciplines or specific (sub) parts of these disciplines. We would then have to state the relationships between those parts, which would not be easy.

In the STEFFIE network that is one way we have chosen to proceed. What we did was to assemble notable figures from the key engineering disciplines, and from academe and industry. We asked them to work together in order to create a coherent community that could, for one thing, act as a valuable supply base to other communities engaged more directly in the process of wealth creation. Interestingly a key criterion in determining specific figures was not just their notability but also their "acceptability" to others. This is a key requirement that gives relationship building a chance of actually happening. So the members, or parts, if you will, are accountable for good relationships. But as this community grows and matures, and its parts change as they learn to become part of the community—real parts rather than simply a priori ingredients in a mix to be created—something emerges which characterizes the community as a whole. What is this? Who knows?

In this article, I offer a view to the question posed by the title—that is, to consider that the parts of the system are only three in number and that they are boundary, emergence, and hierarchy.

The very existence of the notion "part" with respect to the notion "system" re-asserts the fundamental definition of an element of a set. But how can we identify element or set unless we exercise the notion of boundary? One type of boundary identifies the element(s) and the other, enclosing each and every elemental boundary, defines the set. Then again the notion of enclosure is suggestive of, and suggested by, boundary; what others have labeled context (exterior) and content (interior).

Boundaries can have degrees of permeability, ranging from unobstructive to impenetrable, and the value of this parameter can be a function both of time and of the nature of that seeking to transition the boundary.

Whereas boundary is most strongly indicated by topology or geography, we need to be more astute in locating a boundary and therefore in defining what comprises the inside and what lies outside. Where, for example, must the investigators of an aircraft crash construct the system boundary so that they will not overlook the part(s) that caused the failure? In truth a boundary constructor needs to take account of time as well as space. For me, a fundamental part of the system that is systems engineering, is the concept of boundary, and an essential apparatus of the systems engineer is the means to locate and assess a system boundary. Maybe this is known and is the norm. But in my experience the concept is often ignored. Moreover, too many assumptions, possibly of a misleading nature, are made in both analysis and synthesis, as to what constitutes a boundary and how it behaves. The remedy for this, I feel, is for systems engineers to pay greater respect in their work to the processes of abstraction and conceptualization.

And, what about emergence? I must say I've never understood it and yet I believe it. Undoubtedly there is brought into existence, in the creation of a system, a behavior that is meaningful only at the system level, and can in no way be attributable to any subset of its parts. Some argue that this is a consequence of the interconnectedness (structure) and/or interactivity (behavior) among the parts. Maybe so; but what emerges is not always predictable, even though it may be explicable. We know that in synthesizing a system, engineers seek to realize desirable emergent behavior, which would not be realized if a vital part were lacking. The challenge for systems engineers is to acquire a "definer of emergent features" that enables them to minimize unwanted emergent behavior, or at least to be able to predict it and hence seek to mitigate its undesirable effects.

Finally, we turn to the notion of hierarchy. This, like emergence, is intuitively sound and seductively appealing. What we have discovered about nature as being, apparently, a hierarchical structuring of parts into increasingly more complex organizations, we have applied as a pattern to the design of complex systems. Hierarchy is both a tool for classification and a discipline for realization. But we still have a lot to learn in the matter of making hierarchies work, especially those whose main constituent is Homo sapiens. While procedures, processes and "systems" can do much to support the smooth operation of hierarchies, we must still anticipate that these may be flawed and that there may be disconnects of various kinds, e.g. spatial, temporal, and interpretive, between these well-intentioned and well-defined devices and their users. The governance of hierarchical interdependencies, which brings into play our other two concepts of boundary and emergence, is yet another huge challenge for our community.

I have listed three (plus or minus zero) parts. If we were to think on these, in the abstract but also reinforced by our vast collective experience of systems engineering projects, we might then be able to move onto their inter-relationships. We might then, perhaps, find the whole to be a more exciting, innovative and worthy discipline that is systems engineering.

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SE Education in Sweden

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Ericsson, SAAB, Volvo, SKF…The list could be made long. They are all samples of Swedish companies that engineer some of the best systems in the world. Yet none of the approximately 3,500 students that annually graduate with a Master's in Science (MSc) degree after four to five years of study from the seven certifying universities receive a formal degree in systems engineering. The MSc engineering degree is recognized on a national basis and there is no need for additional licensing/certification programs.

Swedish universities, as most, favor the more traditional, specialized disciplines, going as wide as product development and software engineering. No major fault in this, because there is a valid argument that one should only enter the systems engineering arena after having gained experience working on a system in one or more specialized disciplines. However, what is lacking in Sweden is the continuing education that can assist this move.

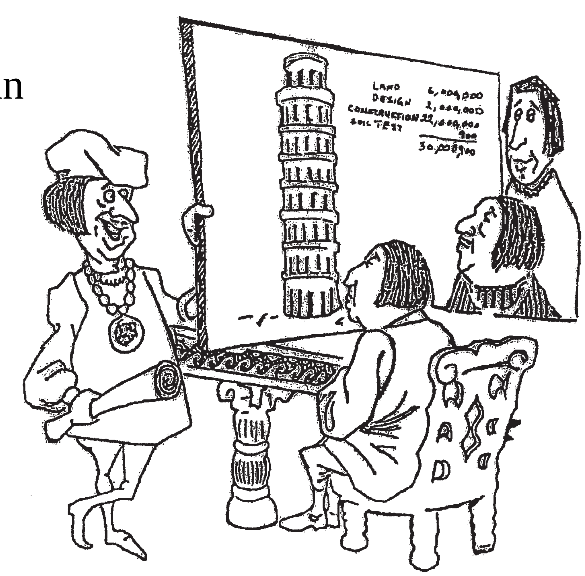
The reason why Sweden can produce such quality systems without formal system engineering education is that we are offered a multi-disciplinary view at work. There is a comparably small engineering community, working in very flat organizations where everybody can take part in the decision making. In this sense, Sweden is blessed by having "natural" integrated product teams.

However, there is a growing appreciation of the need to train and educate engineers to meet the challenges of engineering systems of growing complexity and for the complete life cycle. One response to this is the establishment of a post-graduate doctoral research program in product design called ENDREA. ENDREA stands for the Swedish Engineering and Design Research and Education Agenda, and is a joint collaboration between the major technical universities and industry. The main idea behind ENDREA is to create a national cooperation in creating a new type of research in the engineering design area. (For details see http://www.endrea.sunet.se.)

Also, a series of seminars on different aspects of SE, and an international summer school on SE and Supportability Analysis are conducted with the purpose to establish a wider network and basis for a Swedish INCOSE Chapter (see separate article in this issue of ***INSIGHT***). With just a few Swedish members representing academia, one of the chapter's challenges would be to identify the ways and means to raise the visibility of SE in the university engineering courses. The exchange of information about existing SE programs through the INCOSE Educational Committee is also very useful. The work of the SE Center of Excellence (SECOE) will assist the recognition of SE as an academic discipline. It is my personal thought that the Swedish INCOSE Chapter can provide a pragmatic push for SE education in Sweden.

For more information, contact Tom Strandberg, strandberg@syntell.se.

"…and we can save 900 lira by not taking soil tests."



System Engineering: A Discipline for Unifying Engineering Education

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Abstract. Engineering education is losing its focus as new engineering courses continue to be created. This is not to say systems engineering education is not considered. It does say each discipline's course tends to be taught in isolation. As a result, so much diversity with no visible connection is confusing our students. This contributes to the creation of virtual borders between electrical, mechanical and computer engineers, and induces artificial barriers for teamwork. My viewpoint is as a professor in a country where engineering fundamentals are based on higher abstract training, such as mathematics. While results have been satisfactory, improvement is needed. Such improvement can come by making the systems view central to the educational process. This includes giving students experience in working in interdisciplinary teams. My proposal is that systems engineering core courses be made the nucleus around which all engineering disciplines are centered. Furthermore, it is proposed that curricula be modified to include case studies in core disciplines that can taught in many departments: modeling and simulation, requirements engineering, and validation and verification. In this way all students would be introduced to the basic elements of the system engineering conceptual framework. Process methodology would also be addressed.

Introduction. Mathematics is an essential tool for most scientific disciplines. It is also an excellent way to teach abstract reasoning to engineering students. French engineering education follows this paradigm. Entry to the best engineering schools is based on selection at the A-level of the best college students in mathematics. After two years of training in a mathematics-oriented education, they are again selected to enter the engineering school of their choice.

This system is currently criticized by many eminent French scientists, most notably Messieurs Gilles de Genes and Georges Charpak, recent Nobel prize winners in physics/chemistry. While they acknowledge the importance of mathematics, they make the case that it is not essential for technical disciplines which rely heavily on inductive reasoning, i.e., system engineering. Thus, we have a situation where French industry and government leaders broadly espouse system engineering, but it has yet to be translated into the academic environment. This, in part, is due to a lack of universally accepted definitions and principles.

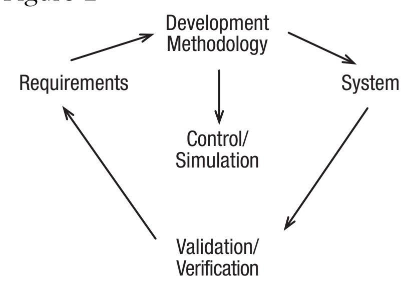
I believe that creating a set of systems engineering core courses for inclusion in all engineering curricula would resolve many of the concerns raised by Messieurs de Genes, Charpak, and others.

Requirements for SE Education: Concept Unification

Based on my experience teaching in universities and industry, SE should be taught as both a discipline and a set of core courses to provide a means for unifying the other engineering disciplines (figure 1).

We may ask what are the essential or core SE concepts? Are they only useful to systems engineers? Experience suggests all engineers can improve their skill set by being taught system thinking.

Figure 2



As illustrated in figure 2 (above), we have a development process that leads to the development of a system meeting a pre-determined set of requirements. Simulation is used to evaluate system behavior. Verification and validation close the loop back to requirements, in order to establish how well system performance meets customer objectives.

Concepts are mapped into core courses. These core courses should contain, in our view, most concepts basic to SE (for example, in methods courses, one finds structuring and abstraction/refinement concepts and corresponding techniques).

From observation, it is clear one course must be structured to teach students system engineering concepts. This course might be named: *A Basic Introduction for Engineer-*

Figure 1

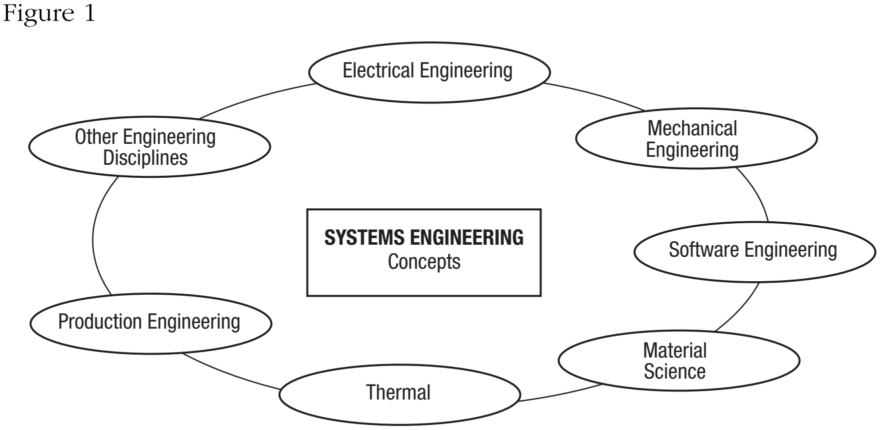
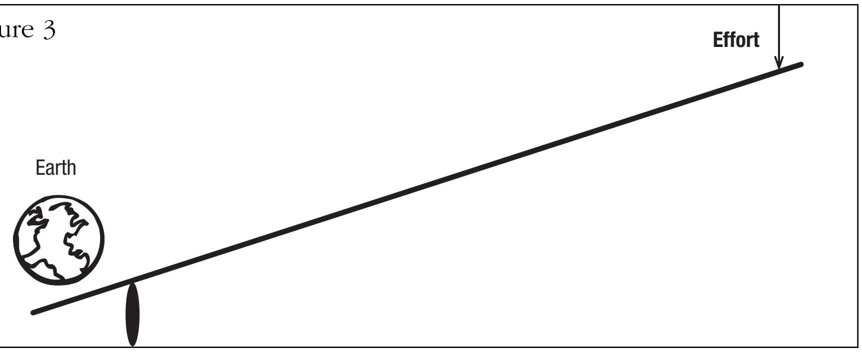


Figure 3



ing a System. Such an approach will teach students how to: 1) avoid redundancy and consistency problems, and 2) convey common knowledge to students so they will, after graduation, know how to work together in engineering a system.

It is beyond the scope of this article to detail concepts contained within each core course. The objective is to define a systems engineering course of instruction using core modules as the unifying discipline for engineering education.

Experience in Teaching Systems Engineering Methodology issue

The value of process methodology (a logical progression of activities) is often not recognized by many engineering educators. Currently, both the systems and software engineering disciplines recognize the importance of having a well-understood design process. These manifested themselves as structured design method in the 1970s and in analysis methods as Structural Analysis and Design Technique (SADT) in 1977. The value of a method is illustrated in Archimedes' statement: *Give me a place to stand, and I will move the world*.

The method corresponds to the application of the mechanical principle of the lever (figure 3). The tool consists of the support and lever. The longer the lever, more powerful the method. However, the technique for pressing on the lever corresponds to the method used. With a good teaching method, students easily mastered concepts such as abstraction, hierarchy, and refined analysis. Similar teaching successes have been achieved at an engineering school specializing in industrial engineering. A typical problem set was to design a gearbox using an object paradigm. Passing software messages should have a counterpart in the gearbox (the linear speed transmission between two gear wheels).

Requirements engineering: Why a requirements step is essential to all technical disciplines.

While all computer science majors are taught the criticality of understanding requirements, many other majors, particularly those where the design process is prominent, do not impress upon students the need to get a good grasp of requirements before starting the design.

One technique used (repeatable) through sixteen short-term projects per year at the technology institute IUT-B (Université de Toulouse le Mirail) proved successful in teaching students the value of requirements. First year students were assigned the task to acquire course requirements by contacting lecturers. Part of the assignment was to write these requirements in a specific format. When it came time for the requirements engineering lecture, the experience helped in raising student interest and attentiveness.

Validation and Verification (V&V) processes.

Most students consider V&V a waste of time. Getting students to understand why the V&V process needs to be embedded within their work has been a major undertaking. Equally daunting has been the task of convincing them the V&V process is needed for both hardware and software. Moreover, the same principles apply for verifying software in computer science or verifying mechanical structure in mechanical systems. Fault tolerance, system reliability, and associated concepts are basic elements in this core module.

To teach this to students, we have experimented with illustrating concepts with simple everyday life examples. For example, getting to a specific place from a requirement based on a map or why negotiation difficulties are often the result of either consistency problems or semantic problems related to bad syntax/terminology, and other things.

Modeling and Simulation

Defining requirements is a modeling process. The requirement process is used to produce an abstract model of the system. Simulation is a means for partially verifying requirements and learning about system behavior. Simulation is also used in many requirement development schemas in order to have an executable specification to avoid having to build a prototype in the initial project phase.

Personal experiments, starting in 1988, with teaching modeling and simulation to all engineering students have shown that most students have little trouble with the concept of working across disciplines to produce systems models. They learn a perspective impossible to teach when modeling is taught in disciplines specific modeling courses. Also clear was that their experience taught them the value of working across discipline to achieve a common objective.

The revival of modeling and simulation as an important tool for such things as the design of numerical systems underlines the importance of teaching students to have a systems view. There is not a problem with each engineering discipline teaching modeling separately. The problem lies with first teaching students to do system modeling. This teaches students why the electrical or mechanical systems they are modeling must be able to interface with the other systems elements. If the students' first college course was one in systems modeling, much of the time spent by the various disciplines teaching modeling fundamentals could be eliminated, and thus increase the time spent on teaching discipline specific modeling techniques. Lacking a core set of systems engineering courses, it is no wonder many of our students graduate with an incomplete understanding of how to engineer a system.

Conclusions

Most European countries expect students to complete a five-year course of study to earn a Bachelor of Engineering degree. The first two years are concentrated on taking foundation courses common to all of engineering. Specialized courses specific to their chosen field of study are taken in the years three through five. Four core SE courses have been identified as being valuable to all engineers. Personal experience suggests that adding one course per year in the second through fifth year would be relatively easy and would produce more capable graduates.

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Professor Abd-El-Kader Sahraoui *is professor at IUT-B institute at Toulouse Le Mirail University and research fellow at LAAS-CNRS Toulouse.*

Working Groups

Notes from the Technical Board Chair

John R Snoderly, Snoderly@dc.jones.com

At the January International Workshop in Mesa, Arizona, I took over as the Technical Board Chair from Donna Rhodes, who is now our President Elect. Donna left the Technical Board in terrific shape with many products underway, as well as a strong leadership team of Technical Chairs. Richard Harwell has replaced me as the new co-chair and Heinz Stoewer has graciously agreed to continue as international co-chair.

At the International Workshop, I addressed some new directions that I would like to see happen during the next year. I favor the idea of our chapters becoming involved in the support and generation of INCOSE products through the technical committees and their respective working groups. To help this theme along, Ken Ptack, our 1999 president, suggested that I get the Southern Maryland Chapter involved with the Systems Engineering Handbook rewriting effort. The SE Handbook was initially published in January 1998, it takes about two years to complete an update. Dick Wray, the Processes and Methods Technical Committee Chair, has agreed to lead this effort and is proceeding to gather support from the other TCs and the SF Bay Chapter, who has agreed to provide an integration function to the project. (Hmmm! Sounds like we are going to use a systems approach!) While we are doing this effort, a definite move should be made to look at making the revised SE Handbook useful to the commercial industries, and not just those involved in defense and aerospace.

One of the important issues facing the Technical Board is the development of an approach to the Integrated Capability Maturity Model (CMMI). As I write this in early March, a draft INCOSE position has been formulated under the able leadership of Sarah Sheard, Chair of the SE Measurement Technical Committee. A final position was due at the next INCOSE Board of Directors video-teleconferencing meeting on 27 March.

Collaboration efforts are also the responsibility of the Technical Board, and Richard Harwell is helping formulate some ideas in this area. There is always a tremendous amount of activity as discussed in this wonderful publication, ***INSIGHT***, thanks to the efforts of Valerie Gundrum and the theme editors who work so hard in getting a professional publication to INCOSE's membership.

Our current technical chairs, listed below, can be contacted through their e-mail addresses listed on the INCOSE web page (http://www.incose.org):

- SE Education & Training
  Dennis Buede
- SE Applications
  Bill Mackey
- SE Measurement
  Sarah Sheard
- SE Modeling & Tools
  Mark Sampson
- SE Management
  Jim Armstrong
- SE Processes & Methods
  Richard Wray
- SE Standards
  James Martin

I hope to see you at the symposium in Brighton!

Measurement Working Group Lengthens Its Reach

Garry Roedler, garry.j.roedler@lmco.com, Don Gantzer, Don.Gantzer@faa.gov, Ken Stranc, kjstranc@tasc.com

It was a scheduling nightmare. There was an endless list of topics on the agenda and the Measurement Working Group (MWG) had only four days at the INCOSE International Workshop'99 to do it all. The greatest challenge was to coordinate efforts on measurement themes with several other groups within INCOSE who were busy conducting their own meetings. We also needed to reserve plenty of time to move forward on MWG projects, share lessons learned reports, and conduct a measurement tutorial. Despite the obstacles, it is a pleasure to report that we were successful on all counts.

Coordination with other INCOSE groups whose work involved measurement was our theme for the MWG at IW'99. Our objective in coordinating these efforts was to establish better horizontal integration between the valuable projects in INCOSE. We met with representatives of three other working groups as well as the SE Center of Excellence (SECOE) group to identify areas where we could work synergistically to improve current work products of each group, and to identify opportunities for common products. One area of common ground is *Frequently Asked Questions*. We invited the other groups to contribute FAQs pertaining to measurement to our Measurement FAQ collection. In addition, we assigned people to serve as liaisons between the groups to identify collaborative opportunities.

The MWG met with the Educational Measurement Working Group (EMWG), which is currently defining how to measure the qualifications of systems engineers. The EMWG has already leveraged many of the MWG's ideas and has gotten off to an excellent start. We agreed to share expertise in providing a technical review of each other's products.

Our discussions with the Tools Integration Working Group (TIWG) focused on the concepts of operations for tool integration that they are developing for several systems engineering areas. The MWG agreed to review concepts of operations that involve measurement, starting with the one for project management. In addition, the MWG will also provide the TIWG with a scenario that demonstrates how we would like measurement tools to work with each other and with other systems engineering tools.

One of the most important reasons for systems engineering measurement is to reduce risk. Therefore, we scheduled a meeting with the Risk Management Working Group (RMWG). We agreed that there were enough issues for the two working groups to collaboratively address to warrant spawning a joint Risk Measurement subgroup. The focus of the subgroup would be measurement support for risk management. This will start with an examination of the risk management process and use the process defined in the INCOSE SE Measurement Primer to identify the candidate measures and data collection to support the process.

The MWG also met with Eric Honour to discuss the Systems Engineering Center of Excellence (SECOE) and its projects. There are clearly areas where measurements will be taken and we agreed that it would be valuable to have the MWG provide critical technical reviews of SECOE ideas, project plans, and methods. Eric asked specifically that the MWG review two current SECOE projects, Systems Engineering Effects, and Systems Engineering Benchmarking, from a measurement perspective.

Highlights of ongoing MWG projects that were discussed at IW'99 include:

- CMMI and Measurement — LTC Joe Jarzombek, USAF, described the CMMI for software and systems engineering that is currently out in draft form. Joe focused on the newly created Measurement and Analysis process area and its implications.
- Emerging SE standards — Ron Kohl updated the group on EIA 632 and EIA/IS 731. Ron will be leading an MWG project to analyze EIA 632 for its measurement related requirements and create a mapping to the INCOSE measurement process defined in the Primer. Don Gantzer will be leading a similar MWG project for the EIA 731 measurement related requirements to create a mapping to the INCOSE measurement process.
- FAQs — With the impending growth in our master list of measurement FAQs, Ken Stranc will draft up selection criteria for adding new FAQs to the list.
- MWG Brochure — The MWG brochure was reviewed and revised. Look for it at the 1999 INCOSE Symposium.
- Practical Systems Measurement Development — The MWG has been leading an effort to extend Practical Software Measurement (PSM) to systems by developing a single set of guidelines for software and systems measurement processes. MWG members are currently writing descriptions of measures that are unique to systems engineering.
- Practical Systems Measurement (PSysM) Tutorial — Garry Roedler, Don Gantzer, and Chris Miller conducted a pilot session of the PSysM tutorial that will be offered at the 1999 INCOSE Symposium in June. Comments were collected and will be incorporated into the course. The tutorial, patterned after the Practical Software Measurement (PSM) course, describes a standardized process for performing systems engi-

neering measurement. It will serve as the draft version of the PSysM course to accompany the guidance that is being prepared collaboratively with the PSM Initiative. This is another major contribution of the INCOSE MWG to this collaborative project.

- Lessons Learned — Don Gantzer presented lessons learned at the FAA with respect to measurement for process improvement using the FAA's integrated CMM.
- Measurement Tools — Bill Farr reviewed the Measurement Information Systems Tool (MIST) whose development has been sponsored by both the Naval Surface Weapons Center and INCOSE. MIST, which provides an automated catalog of measures, is functionally complete and is undergoing a critical review of its contents. Although it is not an MWG tool, Bill also described a new tool called the Evaluator Environment that relates like measurements using a hierarchical framework in order to provide insight into more abstract system features such as survivability or maintainability. Don Gantzer provided a demonstration of the PSM Insight tool for selecting and using software measures. This tool will allow the addition of system engineering measures as well.
- Future Plans — After reviewing several good ideas for future projects, the MWG decided that it will define and launch a new project on effective reporting and use of measurement information. Later in the year we will define a project on assessing the effectiveness of measurement.

Measurement: Frequently Asked Questions

Ken Stranc, kjstranc@tasc.com

Question: How will measurement help me develop plans for my project?

Measurement provides the good basis upon which well-founded plans can be established. If a new project is being planned, measures revealing aspects of execution of a similar project can be invaluable in planning the new project. Measures (like time spent in each phase of development, defect discovery and closure rates, staffing levels over time by discipline, time needed for system integration, testing, etc.) can assist in synthesizing a credible plan based upon your organization's past performance. The past project performance measures aid the estimation of the project currently being planned by providing a knowledge base of actual performance under similar conditions or parameters. Differences between the past project and the one currently being planned are analyzed so the estimates can be adjusted to reflect the different conditions. The historical measures also help when performing a feasibility analysis of the overall plan. Adjustments made for specific differences are analyzed to ensure that the overall plan is still feasible. For example, if cost has been adjusted, but no other project parameter has been adjusted, then inconsistencies will be visible. If the adjustments have created inconsistencies based on past performance data, tradeoff analysis will be necessary to obtain a feasible plan. For projects that are already executing, measures can provide quantitative data that support informed decisions when revising project plans or developing new in-process plans, such as schedule or cost recovery plans or other risk reduction plans.

Question: Are there standard pass/fail values for measures?

Although there are no industry standard pass/fail values, there are some rules of thumb frequently used in industry for a small number of measures. Variance between planned and actual values (for cost or schedule, for instance) is often considered acceptable if it is less than 10%-15%. In some organizations and for some types of projects, tolerances may be less. Not exceeding 50% utilization of CPU or memory for embedded systems, or 50% or bandwidth for communications systems, to allow for system growth over the full life cycle, is another example of an industry rule of thumb. Some measurement target values are set by contract or policy. For instance, most systems are delivered by contractual agreement with all high severity problems (ones that crash the system or render it inoperable) fixed. Technical Performance Measures that reflect key system specifications are another example of measurements whose pass/fail values are often set contractually.

In contrast to standard pass/fail values, you will want to set your own thresholds for the values of certain measures in order to trigger corrective actions. Process engineers know these thresholds as process control limits. For example, if you are producing a product, you may want to achieve a balance between the number of defects detected in a time interval and the number of units produced in that period. In this example, we assume that producing units at a faster rate results in more defects per sample. You can place an upper threshold on the number of defects of, let's say, 30 defects per sample, and a lower threshold of 10 defects per sample. The thinking behind these limits is that if the measured value is anything over 30 defects per sample, you are incurring more rework than is profitable, and when the number of defects drops below 10 per sample, you are producing units at too slow a rate to achieve maximum profitability.

News from Chapters

Midwest Gateway

John Hulsman, Jr., Secretary, john.r.hulsman-jr@boeing.com

The fall and winter months have been filled with a lot of activity at the Midwest Gateway Chapter. The chapter elected and installed officers for 1999. Carol Wilke is the new president and John Adrian is the president-elect (vice president). The complete list of directors and their e-mail addresses can be found on the chapter web site, http://www.incose.org/mdwest/.

In the interest of introducing the advantages of systems engineering to members of other professional organizations and societies in the St. Louis area, the Midwest Gateway Chapter has become an associate member of the Engineer's Club of St. Louis.

The September general membership meeting was held at the Engineer's Club of St. Louis and featured a presentation by Bill Schoening on the history and status of software and system engineering capability maturity models. In December, the second Annual Member Appreciation Banquet was held. In addition to an excellent dinner, the program included a presentation by Stephen McCracken on the political and technical aspects of the Weldon Spring Site Remedial Action Project of the U.S. Department of Energy. Derek Bernett, featured speaker at the January general membership meeting, discussed the system architecture and the engineering and procurement practices of the T-38 Avionics Upgrade Program.

The AmerenUE Nuclear Power Plant in Callaway County, Missouri, was the site of the fall tour. After the drive to the plant and the briefing and tour, some of the attendees voiced the opinion that working at a nuclear power plant was safer than riding in a Suburban driven by an ex-helicopter pilot.

The Midwest Gateway Chapter organized two tutorials at Washington University. In November, Dr. Donald Hurta conducted a lively and enlightening tutorial on the use of multi-attribute utility technique for decision making and risk management. In February, Mr. Dana Clarke led an informative tutorial on the Theory of Innovative Problem Solving (TRIZ).

As the weather in the Midwest mellows, last year's membership survey is being reviewed and plans are being made for future activities.

Space Coast Chapter Elections

Gerard Delaney, gdelaney@harris.com

The Space Coast Chapter, Melbourne, Florida, installed the following officers at the January 7, 1999 meeting:

- President: Joseph Sobierajski, Northrup Grumman
- Vice President: Scott Shenton, Northrup Grumman
- Treasurer: Gerard M. Delaney, Harris Corporation
- Director, Communications: Matt McKaig, Northup Grumman
- Director Programs: Paul Crawford, Northup Grumman
- Director, Membership: Terry de la Moriniere, Harris Corporation
- Directors at Large: Tim Smith, Harris Corporation; Ryan Reid, Northrup Grumman; and Vinnie Simone, Northrup Grumman.

Tom Kabaservice, the Region V Director representing industry is also a member of our chapter.

The Space Coast Chapter meets the first Thursday of every month in the Seventh Floor Conference Room of the Crawford Science Building, Florida Institute of Technology, Melbourne, FL at 5:30 PM. A program follows a sociable half-hour. For details, see our web site: http://www.incose-scc.org.

LA Chapter Spring Conference, April 16-17, 1999

Unifying Systems Engineering Practices

Judith Peach, judith.e.peach@lmco.com

Continuing in the tradition of excellence, Los Angeles Chapter is sponsoring its Spring Conference on April 16-17 at the lovely Pasadena Hilton Hotel in Pasadena, California. The conference will include technical presentations, exhibits, tours and a banquet for INCOSE LA Chapter members and their guests on Saturday night.

Several presentation tracks are designed to support the theme, "Unifying Systems Engineering Practices." Tracks include: Process Improvement, Application in the Commercial and Public Interest Domain, Military and Aerospace Practices, Systems Engineering in Cyberspace, and Vendor Presentations.

The conference experience will be enhanced by tours to the JPL Visual Engineering Laboratory, the Cal Tech Seismic Laboratory, and Fighter Town. The tours will provide the opportunity to see systems engineering in practice and to network with other systems engineering professionals.

"Object Oriented Systems Engineering" will be the topic of a half day tutorial held on Saturday concurrently with the conference. Mr. David Beshore (Systems Engineering Process Leader, Boeing Rocketdyne) will lead the tutorial.

Additional information, including registration forms, and available hotels can be found on the INCOSE LA Chapter Web site:

http://www.incosela.org/

Seattle Metropolitan Chapter (SMC)

Joe Simpson, President,
Joseph.Simpson@PSS.Boeing.com

The SMC is off to a running start in 1999. The "Partners in Industry" program has been established, the Chapter has joined the Puget Sound Engineering Council (PSEC), and four tutorials have been planned for the year, as well as a regional "mini-conference."

President Joe Simpson has established the following four objectives for the year:

1. Provide a regular forum for SE topics and professional networking.
2. Establish an integrated SE training program, including tutorials.
3. Maintain a Web site for international, regional, and local information and interactive discussion.
4. Hold one regional mini-conference, October 1999, Portland, Oregon.

The tutorials currently planned are listed below. Brian Mar is coordinating this activity for the chapter.

- March 20, Decision Making and Risk Management, Dr. Brian Mar and Mr. Barney Morais
- May 22, Understanding Software – The Importance of Requirements, Ms. Dorothy McKinney
- September 11, Conceptual Analysis With Models and Objects, Dr. David Oliver
- November 13, Systems Requirements Analysis, Mr. Jeffrey Grady

The Partners in Industry program has been defined with some very real benefits to joining corporations. Mary Simpson is leading this activity for SMC.

You can find more about the SMC at: http://www.connectexpress.com/~smc-incose/.

San Francisco Bay Area

Dorothy McKinney, President
dorothy.mckinney@lmco.com

Beginning in January, our monthly chapter meetings are held at Lockheed Martin Missiles & Space in Sunnyvale. The presentations from first quarter of 1999 were the following:

- January — "Export Control — Good Politics but Bad National Security Policy?" (Chris Hoeber, Space Systems/Loral)
- February — "Highlights and Insights from the 1999 INCOSE International Workshop" (featuring SFBAC Attendees to the Workshop)
- March — "Requirements Management in the Modern World"(Mark Surles, QSS, Inc.)

Last November, the chapter embarked on the "core series" of tutorials, beginning with "Fundamentals of Engineering Complex Systems" from Mr. Barney Morais and Dr. Brian Mar. In January, Dr. David Oliver presented "Conceptual Analysis with Models and Object" to an enthusiastic group. Dorothy McKinney's popular presentation in October 1998's monthly meeting, namely, "The Systems/Software Engineering Interface: Impact of COTS and New Software Technology Developments," was a precursor to her February tutorial on "Systems & Software Engineering: From Theory to Practice." In March, Mr. Jeff Grady presented "System Requirements Analysis." Sponsoring a comprehensive "core series" is an ambitious undertaking for the chapter and is made possible due in large part to the leadership of Mr. Bob Barter, Chapter President-Elect, and of the chapter board. Please visit our Web site for the latest news on our tutorials (http://www.incose.org/sfbac).

And speaking of the chapter Web site, it has been re-located to its permanent location on the INCOSE server at http://www.incose.org/sfbac. Please visit our members area to see what makes our chapter special to its membership.

Over the years, we have found that offering our members an opportunity to work on a joint activity advances the opportunities to network as well as professional development. The Systems Engineering Handbook was the chapter's first group project. We have enjoyed considerable success and notoriety since its publication. A few months ago, we received an inquiry for its use in a university course. The on-line version of the handbook will be accessible by all INCOSE members on the Internet by the time this article is published. The Systems Engineering Society of Australia received permission from the Technical Board to publish the handbook for sale in Australia. And at the 1999 International Workshop in January, we received concurrence from the Technical Board to lead the effort in revising the handbook. Tim Robertson (timr@sirius.com) and Dorothy McKinney will reprise their roles as editors of the handbook, with Jim Whalen (jtwhalen@earthlink.net) joining the team of lead editors.

We look forward in bringing to the world a new edition of the handbook. John Snoderly and Dick Wray are working with the INCOSE Working Groups to obtain contributions from around the world, not just from the San Francisco Bay Area Chapter. We solicit the assistance of INCOSE members in producing the new edition. Please contact John Snoderly, Dick Wray, or the lead editors to volunteer.

Upcoming Events:

- April 13 — SFBAC Monthly Program. Jim Brill, "Best Practices Guide and Case Study Examples From the French Space Agency"
- April 24 — SFBAC Tutorial. "Risk Management" by Dr. Brian Mar and Mr. Barney Morais
- May 11 — SFBAC Monthly Program. John Hoschette, "Improving Systems Engineering Career Prospects In A Better, Faster, Cheaper World"
- May 22 — SFBAC Tutorial. "High-Performance Technology Teams" by Michele Jackman
- June 8 — SFBAC Monthly

Program. SFBAC monthly meeting. Program to be announced.
- July 13 — SFBAC Monthly Program. SFBAC monthly meeting. Program to be announced.

All SF Bay Area Chapter meetings are held at Lockheed Martin Missiles & Space in Sunnyvale at 5:30 p.m. Check our web site for announcements and directions: http://www.incose.org/sfbac.

All SF Bay Area Chapter sponsored tutorials are held at San Jose State University on Saturdays, 8 am to 5 pm. Pre-registration is required.

Region II Conference Announcement

D.Alex Chuang, President Elect,
alex@revenue.com

The Colorado Front Range Chapter is pleased to announce a Region II Conference on Commercial SE and New Product Innovation and Development. The conference will be held on March 26-28, 2000 at the Hilton Denver Tech South in Denver, Colorado. The conference program will consist of:

- Multiple half-day tutorials (up to four tutorials are planned)
- Paper presentations
- Multiple tracks by industry and/or functional disciplines (three tracks are planned)
- Capstone panel discussion
- Mini-trade show
- And other satellite events to be announced

For more information about call for papers, corporate sponsorship opportunities, trade show participation opportunities, proposals for tutorial, proposals for conference track, serving on the conference planning committee, and other general information, please visit us at http://www.incoseCO.org or contact:

- Conference Chair, D. Alex Chuang, (303) 888-2015, alex@revenue.com
- Conference Co-Chair, Lenny Mell, (303) 814-8733, lemjd@aol.com

INCOSE's 10th Anniversary Symposium in Minneapolis!

Amy Nowakowski
asnowako@collins.rockwell.com

Mark your calendars ***now***. *INCOSE 2000* will be the 10th anniversary of the INCOSE symposium and you won't want to miss it! *INCOSE 2000* will be held in Minneapolis, Minnesota, U.S., on July 17-20, 2000. The first brochure was distributed at the 1998 Vancouver symposium to whet your appetite. More information is available at the *INCOSE 2000* Web site: http://incose.org/nrthstar/Sym2000.htm. A full Web site will be launched this spring with details about *INCOSE 2000* including the call for papers, call for exhibitors, tutorial proposals, and much more. As the symposium nears, monitor the *INCOSE 2000* web site for the latest on sights to see, Minneapolis event calendar, travel information and a complete detailed schedule of symposium events. This web site will also be available for on-line symposium registration. If you are planning to submit a paper for *INCOSE 2000*, you will find the Call for Papers in the INCOSE '99 brochure. Please note that draft papers must be submitted by November 1, 1999.

Visit the *INCOSE 2000* booth at Brighton England for more information on how to attend, become an exhibitor, submit papers and have an impact on the future of systems engineering.

Raising Visibility of Systems Engineering in Sweden

Tom Strandberg, strandberg@syntell.se

With the status of emerging chapter, a number of activities have been carried out to foster a wider recognition of Systems Engineering in Sweden. There are, of course, numerous initiatives that fall within the frame of SE without that specific title. (For more information in this, see the article on SE in the Swedish academia in the theme section of this issue.)

Last year, a series of one-day seminars specifically on the subject of SE was initiated. Leaders in the field make the presentations. They are asked to first present their own/or company view of SE, and then focus on different aspect of SE. In May 1998, Dr. Dinesh Verma, Lockheed Martin, presented an overview of SE and life cycle issues. In August, Tom Gilb, Results Planning, focused on the requirements engineering aspects. In October, Dr. Robert Shishko, NASA JPL, discussed the project management aspects of SE, specifically risk management.

For 1999, we have planned seminars looking at organizational issues of SE, standards development, and modular management. In August, a one-week course on SE and supportability analysis will be held in the archipelago (please see the article in the Industry News section for details).

The objective is that the presentations provide a useful input to the local group for tailoring information to a "Swedish approach." Swedes are generally open-minded and have a systems approach to life, bringing some formal structure to it. I think we can offer something to the SE community. We would welcome any visits, so please let us know if you are "passing by" and would be willing to share your experiences, thoughts, and ideas.

INCOSE Infrastructure

Systems Engineering Network Of Excellence (SENOE)

Eric Honour, ehonour@hcode.com

As an international organization, INCOSE is fostering its goals in many countries. There have been several articles in ***INSIGHT*** concerning the (primarily) United States-based SE Center of Excellence. There is, however, a larger INCOSE structure into which SECOE fits.

At the International Workshop '98 in Dallas, initial charter meetings for SE research initiatives included members from at least four countries. These meetings created the concept for the SE Network of Excellence (SENOE). This loosely affiliated network falls under the INCOSE Education & Research Technical Committee (ERTC) and will include relationships with INCOSE research organizations across the world. The administrative leaders of each group coordinate with other groups through e-mail, the Internet, and INCOSE meetings. A new INCOSE Research Advisory Board, yet to be created, will encourage specific research topics through an agenda coordinated with and grown by all groups.

In addition to the U.S.-based SECOE, other groups exist in both U.K. and India. As an outgrowth of the Technology Foresight reports in U.K., the Engineering and Physical Sciences Research Council (EPSRC) has provided partial funding for the STEFFIE research project (Systems Engineering Framework For Information and experience Exchange). STEFFIE is based at DeMontfort University with six other academic partners. A nascent SE Center of Excellence in India is based at the Indian Institute of Technology in Bombay.

New INCOSE research groups from other countries are welcome and invited to coordinate through this Network of Excellence.

Taking INCOSE into the 21st Century

Donna H. Rhodes, INCOSE President Elect, donna.rhodes@lmco.com

As your new President Elect, it is my responsibility to lead the development/refinement of the strategy and technical operating plans for INCOSE. INCOSE has a Strategic Plan for the organization; however, this is at a general level. During the next year, I will be focused on creating the INCOSE Strategy 2000, a comprehensive five-year strategy to take our organization into the next century. This will have two components:

1. ***Strategic Directions*** — a document describing INCOSE's vision, mission, core values, and strategic goals in four key areas:
   - Growth, diversification, and globalization
   - Influence and advancement (of the art and the practice)
   - Governance
   - Infrastructure
2. ***Strategy2000 Master Plan*** — a detailed plan defining the specific initiatives and underlying investment plan to achieve the strategic goals.

Initial brainstorming activities toward a five-year strategy were collected at the July '98 Symposium, and a follow-on retreat session of the Board of Directors (BOD) explored specific areas in more detail. After this meeting, a Strategy Subcommittee was formed, comprised of past and current INCOSE leaders, including BOD and Technical Board officers. During the '99 International Workshop, the subcommittee further developed many of the ideas previously generated, and members of the BOD participated in working sessions to refine these in more detail.

The *Strategic Directions document* will be completed prior to the INCOSE 1999 Symposium. This document will serve as a "communication/marketing piece" that can be used to communicate INCOSE's strategic goals to existing and potential sponsors and members. Several review cycles are planned and will involve the BOD, Corporate Advisory Board (CAB), Technical Board, and the chapters (via the chapter president).

In the following months, the *Strategy 2000 Master Plan* will be developed, and mapped to the existing *Technical Operating Plan* and the *Technical Products & Services Plan* (developed by the Technical Board). The Master Plan will detail demographics, specify roadmaps for initiatives, accomplishment criteria, and measurable outcomes for each goal. Investment plans will be part of this master plan. Active participation from BOD, CAB, Technical Board, and chapters will be key to a successful outcome. In addition, a formal *INCOSE Annual Report* will be published to report progress and communicate the increasing value of INCOSE to membership and sponsoring organizations. In the future, surveys will be implemented as part of the ongoing membership/renewal process. The measurement data derived from these surveys will provide indicators of progress against goals and overall member satisfaction.

INCOSE Membership, An Excellent Value

Lew Lee, lew.lee@trw.com, Dona Lee, donalee@dynsys.com

By any measure, a membership in INCOSE is a very good value for the practicing systems engineer. We look forward to receiving our quarterly issues of ***INSIGHT***. We enjoy excellent pricing for INCOSE publications. We can contribute to the highly informative Journal of Systems Engineering, now published on a regular basis by John J. Wiley & Sons. We make day-to-day use of important resources like INCOSE's World Wide Web site and the discussion list server to find information to help us in our work. Many of us take part in one of INCOSE's many working groups or attend local chapter meetings. And this list grows longer and better with each passing year.

In 1998, the INCOSE Board of Directors appointed a committee led by Tom Kabaservice, Region V Director to examine INCOSE's current fee structure and the resources needed to make INCOSE's future plans for growing technical activities and improving communications a reality. Tom and his committee studied comparable professional societies and looked carefully at INCOSE's future financial situation. The committee included representatives from the Chapters and Membership Committees, U.S. and non-U.S. members.

Based on the committee's recommendation, the INCOSE Board of Directors approved an increase in dues for members from $60 U.S. to $80 U.S. effective with the start of the membership year on June 1, 1999. This is the first increase since INCOSE was founded almost ten years ago. Student membership dues remain at $10 U.S. In their final report, the committee also noted that at $80, INCOSE membership remains a bargain compared to other international technical and professional societies.

A very positive message accompanies this dues increase. The financial analysis shows that individual member dues make up less than half of the total income required to sustain INCOSE's activities. Reinvestments make up the balance. Support from the Corporate Advisory Board and the financial success of yearly symposia are "reinvested" in the workings of INCOSE. Chapter activities will continue to be supported at current levels from dues contributions.

So when your annual renewal notice arrives in your mailbox this spring, return it promptly so you don't miss out on any of the valuable benefits that membership in INCOSE brings you!

Jim Armstong, New Technical Committee Co-Chair

Bill Schoening, schoening@inlink.com

I would like to announce the appointment of Jim Armstrong as co-chair of the INCOSE Systems Engineering Management Technical Committee. Elaine Hall is the other co-chair, and Rich Harwell has become co-chair of the Technical Board.

Jim has been a frequent and popular author and presenter at INCOSE symposia including "Systems Engineering Compared," which was best in track in 1993, and "How Maturity Modeling Saved My Softball Team" in Vancouver. Jim's broad experience as a systems engineer (coupled with a keen wit) have led to frequent appearances as a session chair and panel moderator.

Jim has been an author and reviewer of EIA-632, EIA/IS-731, IEEE 1220, and the IPD CMM along with other standards and models. He is the current president of the Washington Metro Area chapter following a year as vice president, and has been one of its directors in the past.

Technical Committee chair is as much about leadership as it is about technical expertise. Throughout his career in industry and INCOSE, Jim has demonstrated balanced skills in both areas. We are fortunate to have someone with Jim's experience, energy, and dedication to INCOSE as a co-chair of the Systems Engineering Management Technical Committee.

I would like to express my thanks and appreciation to the Software Productivity Consortium for whom Jim works. It is their support that makes it possible for Jim to participate in INCOSE.

Rich Harwell New Co-Chair of Tech Board

Bill Schoening, schoening@inlink.com

I would like to announce the appointment of Richard Harwell as co-chair of the INCOSE Technical Board. Rich has long been active in the INCOSE's technical community as well as one of our very first members. Rich joins Heinz Stoewer and John Snoderly, who is now the chair, to lead the Technical Board.

Rich became co-chair of the Requirements Working Group in 1992, and then co-chair of the Systems Engineering Management Technical Committee in 1995. In 1995 he formed and chaired the SE Management Methods Working Group in addition to his Technical Committee role.

Under Rich's leadership, a Systems Engineering Technical Committee Working Agreement was put into place between INCOSE and AIAA. One of the first products of that cooperative venture is the INCOSE/AIAA Systems Engineering Brochure.

Rich was INCOSE's representative to the four-person technical committee for ANSI/EIA-632, Processes for Engineering a System, and an INCOSE member of the EIA SEWG for that standard. Along the way, Rich has found time to author and present a number of papers at INCOSE symposia.

After retiring from Lockheed Martin this past year, Rich is starting SYSTEM Perspectives, a consulting firm specializing in systems management, engineering processes, and business processes.

We are fortunate to have someone with Rich's experience, energy, and dedication to INCOSE as a co-chair of the Technical Board.

Obituary

Gregory Augustine

Gregory E. Augustine of the Colorado Chapter of INCOSE, and program manager for Lockheed Martin Corporation, died March 8 in Boulder. He was 35. Greg earned a bachelor's degree from Texas A&M University and a master's degree from the University of Colorado. In addition to being a member of INCOSE, he was an Eagle Scout, a Red Cross disaster relief worker, and a member of Tau Beta Pi and the Texas A&M Alumni Association. He is survived by his parents Norman and Margareta, Potomoc, Maryland; and a sister, Rene, Bethesda, Maryland.

Contributions in Gregory's name can be made to: The Association of Former Students, PO Box 7368, College Station, TX 77844, attn: Memorials, The Greg Augustine Memorial Scholarship.

People on the Move

Sam Alessi has recently moved from Lockheed Martin Idaho Technologies Company to the U.S. Department of Energy Idaho Operations Office to fill a position as Systems Engineering Program Manager. The move was across the street. Sam can be reached (208) 526-1136, or alessirs@id.doe.gov.

Ernst Fricke recently successfully defended his doctoral thesis at the Technical University of Munich, Germany. The title of his dissertation was "Der Aenderungsprozess als Grundlage einer nutzerzentrierten Systementwicklug (The change process as a basis for a user-centered system development)." Ernst wants to leave his position at the university in the next few months. Until then, he can be reached at E.Fricke@lrt.mw.tu-muenchen.de.

Ginny Lentz of United Technologies Corporation has moved from the Research Center to Otis. Ginny can be reached at virginia.lentz@otis.com, or (860) 676.5287.

Herbert Negele has recently been honored with his doctoral degree from the Technische Universitaet Muenchen (Technical University of Munich), Germany. The title of his dissertation was "Systemtechnische Methodik zur ganzheitlichen Modellierung am Beispiel der integrierten Produktentwicklung (A Systems Engineering Method for Comprehensive Modeling Applied to Integrated Product Development)." Herbert intends to substitute his position as an assistant professor with an interesting job in the non-academic world in the next months. Until then, he can be reached at H.Negele@lrt.mw.tu-muenchen.de, except in April 1999.

Kal Toth has recently joined Technical University of British Columbia, in Vancouver, as an Assistant Professor. The new Technical University of British Columbia is being established to meet specific needs of the geological area. The formation team is in the process of creating advanced, but practical, graduate and undergraduate programs using innovative delivery methods (e.g., web-based tools, multi-media) and industry-focused approaches (e.g. modular, applied). Starting this September, three main program streams will be offered: Management & Technology, Information Technology, and Interactive Arts. Kal can be reached at (604) 586-5286, or toth@tu.bc.ca.

Booz, Allen & Hamilton Inc. has joined the Open GIS Consortium (OGC), planning to increase its global impact through expanded participation in the Defense & Intelligence and Disaster Management Special Interest Groups. **Jack Welsh**, a Principal with the Firm, will serve as the Firm's Business/Marketing representative, and **Dr. Rich Johnson**, an Associate, will serve as the Technical representative. Both are active INCOSE members and can be reached at welsh_jack@bah.com and johnson_richard@bah.com, respectively.

Industry News

Progress on STEP AP-233 "Systems Engineering" Data Exchange Standard

Julian Johnson, julian.johnson@bae.co.uk, and Sylvain Barbeau,
sylvain.barbeau@espace.aerospatiale.fr, ESPRIT Project 20496 "SEDRES"

During the same week in January that INCOSE technical participants were working hard at the International Workshop in Mesa, Arizona, there was another international meeting taking place over on the West Coast in San Francisco. This was a meeting of the technical committees and working groups (WGs) of the ISO TC184/SC4 organization (home page at http://www.nist.gov/sc4/). The scope of TC184/SC4 covers the ISO standard STEP (ISO 10303), and it is under this organization that work on AP-233 is being undertaken.

With the AP-233 team organization established at earlier meetings, during January the emphasis was on earnestly making progress on the AP-233 deliverables. Technical discussions developed the Requirement Document further, and a walk-through of the third input into the AP-233 activity from SEDRES (a draft data model now incorporating system architecture aspects) enabled it to be accepted by the WG as the Second Working Draft. This document, now identified as N779, will shortly be uploaded to the TC184/SC4 server, and demonstrates real progress being achieved within the WG.

There were fruitful discussions with many of the other WGs, including T19 (covering AP214, the Automotive STEP Application Protocol), and input from the INCOSE Tools Integration and Interoperability WG faxed "hot" from Mesa. INCOSE also noted its intention to put in place a liaison between INCOSE and ISO TC184/SC4 that would ensure INCOSE interests are represented, although the exact mechanisms to achieve this are still being explored. This liaison should formalize the active two-way communication that already exists between the INCOSE and AP-233 communities.

The group concluded the week with agreement on tasks to progress the work further. These activities will focus on several items: the Requirement document; the AAM (Application Activity Model, a contextual process model); the ARM (Application Reference Model, a data model capturing concepts directly recognizable to practicing systems engineers who would use the data exchange capability); and the part of the data model covering Systems Requirements. Finally, an agenda was agreed for the next AP-233 working group meeting coming up in June 1999 – coincidentally, the same week as the INCOSE International Symposium! We'll look forward to using the same "hot fax" technique again.

The interested reader may like to note that, despite this meeting conflict, several of the SEDRES partners will be presenting three papers on the project work that led up to AP-233 at the INCOSE symposium in Brighton, and conducting a half-day tutorial that will cover SEDRES, STEP, and AP-233.

If you are interested in actively contributing to the AP-233 development process, please make contact with either of the authors of this article.

Ann Gisch Earns ANSER Excellence Award

News release, February 11, 1999

Ann Gisch of the Washington Metropolitan Area Chapter, International Council on Systems Engineering, earned the ANSER Excellence award from her employer while working on the Headquarters Air Force (HAF) information architecture planning (IAP) team. ANSER Inc., a public service research institute that focuses on national and international issues, is based in Crystal City, Va. The IAP team delivered a Strategic Information Management Plan to modernize the HAF information management practices and provide faster service to its customers. Mrs. Gisch, who has a strong background in information architecture, directed her efforts to projects involving human resource information management. She is continuing their work into the implementation phase of the strategic plan.

For further information, please contact: June Forte, (703) 416-1370 or June.Forte@pentagon.af.mil

The First Scandinavian Summer School on Systems Engineering and Supportability Analysis

15-20 August 1999

The school will be held for a global audience in a local setting in the Stockholm Archipelago, Sweden.

This school will discuss fundamentals of systems engineering, along with methods and tools to integrate supportability engineering and logistics concepts and principles into system design and development. Emphasis will be on increasing system operational effectiveness while simultaneously reducing life-cycle cost. Course directors are Dr. Jezdimir Knezevic, MIRCE Research Centre, and Dr. Dinesh Verma, Lockheed Martin. Information is available at http://www.syntell.se.

Enquiries: Tom Strandberg, Syntell AB, Phone +46-(0)8-660 02 80, e-mail: strandberg@syntell.se.

IEEE Standards Are Taking the Fast Track

James N. Martin, Chair, INCOSE Standards Technical Committee, j-martin@ti.com

The IEEE has taken steps to shorten the development cycle for standards. With much of industry decreasing the product development cycle, standards are becoming of less value since their development sometimes takes longer than the life of the product itself.

The following article is a reprint from an IEEE publication and describes the new IEEE Standards Association. Its charter is to shorten the time in developing standards. This move by IEEE is a significant step forward in increasing the value of standards for product and system development.

The INCOSE Standards Technical Committee is chartered to keep the INCOSE membership informed of standardization activities. Our committee is working to establish a formal liaison relationship with the IEEE so that INCOSE can participate in development of standards that affect the engineering of systems.

Association Breaking New Ground in IEEE Standards Development

Greg Gillespie, Editor, THE INSTITUTE, ggillesp@ieee.org

The IEEE Standards Association (IEEE-SA) continues to build its corporate and individual membership as it establishes itself as the IEEE's answer to the changing face of international standards development.

IEEE-SA was established January 1, 1998 to quickly and creatively meet the demands for standards in emerging technologies, especially information technology. The IEEE-SA also broke new ground by seeking corporate membership, making it the first IEEE entity in history to seek direct corporate support for its activities.

Membership Growing. A number of companies, including Hewlett-Packard, IBM Corp. and Advanced Hardware Architecture, Inc., have already joined, along with the U.S. government's National Communications Systems. In addition, over 1,400 individuals now have IEEE-SA memberships.

IEEE-SA corporate members are entitled to such benefits as voting privileges in the governance of the standards program; opportunities to join special industry advisory and liaison groups to make visible their industry's directions, standards priorities, and business needs; participation in the establishment of consortia programs within the framework of the IEEE-SA; and a platform in the IEEE to publish needed industry-specific technical information in addition to standards.

For individual members, the primary benefit is a direct voice in the governance of the IEEE-SA and how the organization is run, by the privilege of voting for IEEE-SA officers. Other benefits include voting privileges on standards in ballot, and eligibility for special offers and premiums on select IEEE standards products and services.

Teaming Up. Efforts are underway to continue the IEEE-SA membership growth at both a corporate membership level and for individual membership. One recent effort was a partnership between the IEEE-SA and the IEEE Computer Society in a mailing campaign designed to raise awareness about the IEEE-SA and solicit new individual membership in the IEEE-SA, Computer Society, and the IEEE.

The mail campaign focused on the benefits of membership in the IEEE as well as in IEEE entities. The Computer Society is one of the leading society sponsors for IEEE computer-related standards. The campaign was also an effort to make Computer Society affiliates aware that in order to vote on a sponsor ballot standard, members of the balloting group needed to be IEEE-SA members effective June 1, 1998.

For more information, contact Karen McCabe, IEEE Standards: (732) 562-3824, e-mail k.mccabe@ieee.org

Summing up my Tenure as a Congressional Fellow

Fred Martin, fsmartin@earthlink.net

In summoning up remembrances, and looking over my monthly notes describing some of my activities as a Congressional Fellow, I am reminded of a question posed to me by an old friend from my days in high-energy physics. Art R., who has spent the last six years as a specialist on energy efficiency at DOE, wanted to know if I had left some sort of mark on Washington! I don't recall my answer, but whether or not I left a mark on Washington, D.C., I can say with some certainty that it left impressions on me.

That 1998 was a very political year is one impression I received. A great deal of posturing and sloganeering transpired, but beyond filling various "rice bowls" extra full in the this year of budget surpluses, little else of substance was accomplished; except, of course, the Republican Party got a modest kick in the shins at the end of the year. Although less than fifty percent of the voting public participates in the elections, it is still possible for the party in leadership to be rebuked by those that do vote.

The Senate Committee on Energy and Natural Resources

I started off the year in the Senate Committee on Energy and Natural Resources (Chairman Murkowski of Alaska) working for the Subcommittee on Energy and Environment (Chairman Nickles of Oklahoma), with majority staff members, Dave Garman and Howard Useem. Howard Useem worked for Senator Murkowski on electric power deregulation. Dave Garman, the person for whom I went to work, managed a hodgepodge of energy and environmental issues for Senator Murkowski. Neither Dave nor Howard had any formal technical training or experience related to the issues confronting the subcommittee, and Senator Nickles appeared to be totally disengaged from these activities. Initially, a number of seemingly important issues were bandied about:

- U.S. participation in the Large Hadron Collider
- Soy oil supplements to diesel fuel,
- Mining deep ocean sediments for methane,
- Environmental regulations for decommissioned power reactors, nuclear waste disposal,
- Manufacturing tritium, and,
- The Department of Energy budget, with emphasis on research and development.

In dealing with these issues there seemed to be several a priori axioms as the starting point: we hate Clinton, foremost; and Democrats are obstructionists, and Republicans are the only true environmentalists, comments of the press notwithstanding. Laboring under this mantra would seem to be a rather unproductive process.

So what happened to the issues?

Unfortunately, the staff member for whom I worked, Dave Garman, left his position shortly after I arrived. It was left vacant, and no one else seemed to have the slightest interest in a Congressional Fellow. This event ultimately obliged me to find another position. However, we did hold some briefings on two bills. One concerned soybean oil supplement to diesel fuel and the other the mining of methane from methane hydrate in deep ocean sediments.

The principle motivation for the Bio-Diesel Fuel Bill S. 1141 (Johnson, South Dakota) to supplement diesel fuel with soybean oil is to expand the market for soy bean farmers — corporate affirmative action at its best. Ancillary considerations included disposing of used cooking oil from restaurants and the reduction of particulate emissions from diesel engines. The proposed legislation modifies the Energy Policy Act of 1992. The original Act included provisions regarding subsidies to encourage the use of alternative fuels derived from farm products, y-clept "bio-mass fuel" or "bio-fuel," for "light vehicles." This legislation expands those provisions to include additives to petroleum diesel fuel for heavy vehicles, stationary diesel engines, locomotives, marine engines, etc. These policy issues concern DOE activities and since DOE already had a program to deal with this supplement, the proposed legislation was not particularly essential. I do not know what happened to this legislation.

Methane Hydrate, S. 1418 was legislation that banned the use of commercial power reactors to produce nuclear weapons material. As of mid December, DOE had not made an announcement on the future production of Tritium.

After firmly establishing my reputation as a loose cannon (as far as the Committee was concerned), I relocated to the Congressional Research Service (CRS). At the CRS, there was a definite interest in my background, whereas some of the other possibilities were more tentative and tepid.

The Congressional Research Service — Division of Science, Technology, and Medicine

At the CRS, I joined the staff in the Science, Technology, and Medicine (STM) division. Eric Fischer was the manager, and I went to work with Mike Davey, who handled many of the defense-related issues that came to the Division.

Legislation drives the CRS activities and its 700 plus employees; it works exclusively for Congress and its research products are available usually only to Congress (although Congressional offices can provide reports, etc., to constituents). At the request of Congress or on its own volition, CRS prepares reports and briefs on issues of concern to the legislature. CRS also provides phone consultations, one-on-one briefings in Member offices, general seminars, and workshops for staffers and officials on Capital Hill. CRS treats all requests from Member and committee offices as confidential, and prepares materials exclusively for that office. General reports and issue briefs are becoming available on a Congressional Intranet. In the legislative process, speed and timeliness are paramount and many requests are reported back within 24 hours. Also, CRS anticipates the legislative priorities for the session and prepares reports, briefs, and updates in advance covering legislative issues.

The STM Division employs about 41 persons, plus one or more gratuitous persons like me. Thirty- five are analysts, and in 1997 they produced approximately 50 written reports, as well as consultations, hearings, briefings, and seminars.

CRS does face a crisis, of sorts, in the coming decade. Because of the large increase in personnel during the 1970s, more than 50 percent of CRS employees will be eligible for retirement by the year 2006. In the Division of Science, Technology, and Medicine, only one of the 35 analysts is under the age of 40. With the declining budget, in real terms, hampering the hiring of new analysts the CRS faces a real challenge in maintaining its institutional memory beyond the next decade, a necessity in order to continue quality service.

My Task

For well over a decade the Air Force has been quietly working on developing and perfecting an airborne laser weapon for shooting down airborne threats. Iraq's deployment of SCUD missiles in the Gulf War gave an added impetus to this effort, and recent efforts in North Korea and Iran to deploy short and medium range missiles have increased the sense of urgency for an airborne laser. The Air Force is currently building a prototype for this weapon. Mounted in a 747, the airborne laser weapon includes a chemically powered, multi-megawatt laser, and two laser radars to track the missile and measure the atmospheric turbulence for beam compensation. The prototype was scheduled for test and evaluation in 2003, but has been put off until 2004 because of budget cuts in the 1999 budget.

Using my background in airborne laser communication, I launched into a detailed technical study of the Air Force program. The study took me to the Lincoln Labs, TRW, and

Lockheed Martin, as well as a number of interviews and briefings locally in the Washington, D.C. area. The study delved into the intricacies of optical tracking at hundreds of kilometers, adoptive optics systems for modulating a laser beam wave front to compensate for atmospheric distortion, and the time it would take a high-power, diffraction-limited laser beam to heat the missile shell to the point of elastic yield, which would lead to the collapse of the missile from internal stresses.

Although we had hoped to have the study available by the time of the budget negotiations in September, our schedule was no more accurate than the Air Force's schedule for the airborne laser. As of February 1999, a draft report has finally gone to the Air Force and others for review, and so we can anticipate a completed report about a year after we started the study. One of the features of our report, which I believe is relatively unique for the CRS/STM, is the depth of the technical detail. We have shown how one can make simple computations on the lethal range of the weapon by making assumptions about the propagation of the laser beam through the atmosphere. It would be interesting to know if, in the future, any of the Hill staffers use the report to make their own assumptions for estimating the lethal efficacy of the airborne laser. This level of technical detail is rather rare in CRS/STM reports. Anyone interested in the report when it is issued should contact Michael Davey at the CRS, or their congressman or senator for a copy.

Several minor projects to look up information or explain technical concepts for Hill staffers also came my way.

General Impressions

During the course of my Fellowship, I interacted with other Fellows and learned about activities in some of the elected offices; projects and issues covered the national spectrum — there is something for everyone.

I also had the opportunity to follow the hearings on the International Space Station (ISS) and other science projects — these hearings provide an interesting show. The 15 or so members of the House Committee on Science held a series of hearings on the ISS, its problems of cost and schedule overruns, and the contributions of the Russian Space Agency. Several witnesses testified that the Russian Space Agency is moribund and cannot meet its commitments to the ISS without massive infusion of U.S. dollars. Although the launches of the first components last November represented a much-needed milestone, the next major module comes from Russia, which could demand exorbitant funds to complete it. Parenthetically, I am told that the relativistic gravity probe project at Stanford University employs several young space engineers from Russia, which mirrors in some degree the demise of space science in that country. What comes through in the hearings on the ISS is that the members of the Committee haven't a clue about the engineering, science, and organization that goes into a project such as the ISS.

Capitol Hill shows signs of concern for research and development programs, and the funding for them. The pursuit of research and development in Congress probably has less to do with the science policy set forth in the Vannevar Bush memo of 50 years ago, and more to do with bringing Federal Funds to Congressional Districts. Nevertheless, Congressman Ehlers (R-MI) has formulated a new science policy document to replace the Vannevar Bush memo. Concurrent with the effort to develop a new coherent science policy for Congress, several bills have been circulated that would set guidelines and authorize R&D funding with a goal of doubling Federal R&D outlays over the next 10 or 12 years. The new policy fails to recognize some subtle and not so subtle shifts taking place in science and engineering as our society becomes more complex and more a network of tangled webs. One that clearly stands out, in the discussions on science, is the preponderance of interest in the bio-medical sciences. These amount to about 40% of the total R&D budgets supported by the Federal Government. Second, there is a shift towards the increasing use of multi-disciplinary task forces to deal with technical and social issues in our society. Some of my thoughts are described in more detail in a separate memo on the Ehlers' Report. (Contact me if you are interested in receiving this.)

Working on the Hill is generally a young person's game filled with activity and enthusiasm. The hours are long, the pay is low, and the turnover time is about two years. Older staff members are usually found in committees, but some offices will have an older staff person, particularly in the Senate. Very few of these folks have any experience in the commercial, business, or R&D world. They are, however, the writers of the legislation — legislation that somehow simultaneously satisfies the constituency of the elected official and the broader issues of public policy. Success is always in the details, and when legislation deals with complex technologies, then outside expertise is sought. It comes from a variety of sources: the CRS, lobbyists, think tanks, agencies, and (yes!) congressional fellows. Many congressional fellows are themselves young and well educated, but inexperienced in the ways of the world of commerce, business, and R&D. The legislative process would well benefit from the congressional fellow who has the experience of working in the "real world." He or she will also be well positioned to absorb and appreciate the experience of working on the Hill.

Frederick Martin, *IEEE 1998 Congressional Fellow, can now be reached at 375 San Mateo Drive, Menlo Park, California, (650) 323-4019.*

The Information ByWay

Systems Engineering, The Historical Perspective

Jack Fisher, Seajnf@aol.com

Two recent works have provided considerable insight into the history of systems engineering. Thomas Hughes, the Mellon Professor of History and the Sociology of Science at the University of Pennsylvania, chronicles the development of four systems[1]. These include the 1950s development of an early air defense system, the Semi-Automatic Ground Environment (SAGE), and the Air Forces development of the early ballistic missiles, as well as ARPANET/Internet and Boston's Central Artery/Tunnel. The purpose of Hughes' work is to describe the changes in management and engineering approaches that were required to develop these complex systems.

Stephen Johnson, an assistant professor in the Department of Space Sciences at the University of North Dakota, describes an approach that he labels as Systems Management[2]. He defines Systems Management as "a set of organizational structures and processes whose goal is to rapidly produce a novel, but dependable technological artifact within a predictable budget" (or in other words—an approach used to design and develop systems). The material for Johnson's work is largely drawn from his PhD dissertation[3] at the University of Minnesota.

Johnson notes that in World War II and the succeeding cold war environment, scientists, engineers, and managers in the defense community were faced with developing new and complex military systems with little or no relevant experience. They responded in different ways; scientists with a mathematical approach based upon their academic experience which became known as Operations Research (OR), engineers developed methods of communicating across interdisciplinary boundaries which evolved into Systems Engineering (also referred to as Systems Integration), and managers developed new process controls and organizational approaches that soon become known as Project Management. Each of these approaches allowed that group to respond to the needs of developing new systems and new processes for using military systems. Johnson thus divides Systems Management into three distinct constituent elements: Operations Research, Systems Engineering, and Project Management[2].

Hughes[1] provides several definitions of Operations Research including "the application of scientific methods, techniques and tools to the problems involving the operation of the system so as to provide those in control of the system with optimum solutions…" According to Hughes[1], Johnson[2] and Buderi[4], Operations Research had its origins in Great Britain in the 1930s when it was proposed that a committee of scientists be established to consider "methods of defense against hostile aircraft." Radar was being developed at the time with the principal focus on the detection of aircraft. However, this new invention could not achieve its full potential without being integrated into an overall air defense system. The scientists helped to devise a system to collect the detection data from the radar sites and direct the RAF fighters to the vicinity of incoming enemy aircraft.

Operations Research migrated to the United States during the war and was used to study a variety of problems. One group at Douglas Aircraft studied means of improving the use of the B-29 bomber. This group was spun off from Douglas in 1946 and became the RAND Corporation. At RAND, the emphasis turned to the consideration of new systems for the Air Force. This approach, which became known as Systems Analysis, could then be used to study future operations and devise requirements for prospective new systems. Systems Analysis subsequently became the centerpiece of Robert McNamara's reign as Secretary of Defense in the 1960s, when quantitative analysis became the means for making decisions on future defense systems and the conduct of the war in Vietnam.

In the 1950s Lockheed and possibly other companies began using Operations Research (OR) to study submarine warfare and evolve requirements for new anti-submarine warfare systems. By the middle 1960s the application of Operations Research or Systems Analysis to the development of new systems had been well integrated into Systems Engineering and was recognized as an essential ingredient. The charter of Systems Analysis was to perform any analysis required for the design of a new system, particularly analysis of the mission to be performed.

Another major development took place as a result of the arrival in the U.S. of the cavity magnetron from Great Britain in 1940[4]. This amplifier, capable of generating 10kw at a frequency of 3 Mhz, was the basis for the British development of microwave radar. Access to this technology plunged the U.S. defense establishment into the design and development of many varieties of radar. The hub of this activity was the Radiation Laboratory (known familiarly as the Rad Lab) at the Massachusetts Institute of Technology.

Scientists at the Rad Lab undertook the development of a radar-controlled system to direct the fire of anti-aircraft artillery[4]. This work was directed by Ivan Getting, a young former Rhodes scholar, who recognized the importance of designing the system components to take into account the performance of the system as a whole rather than that of the individual components. The key breakthrough of an analog computer to process the radar data took place at the Bell Labs. The completed system consisted of the SCR-584 tracking radar, the M-9 gun predictor, and a battery of anti-aircraft artillery. When combined with the proximity fuse this system proved very effective over the remainder of World War II. During the V-1 "buzz bomb" assault on London in 1944 anti-aircraft artillery directed by radar had a kill rate of 60%.

Development of military aircraft in the U.S. during and immediately after World War II was based upon separate procurement and development of the airframe, engine, armament and electronics. Thus, Johnson[2] notes that as aircraft became more complex with the advent of jet engines, guided missiles and radar, the airframe and its components became more tightly coupled. Further, it was only after the aircraft was designed that support of the system in the field was considered.

In 1951, Colonel Bernard Schriever undertook a study of combat aircraft procurement practices for the Air Force. Schriever, in his report entitled Combat Ready Aircraft, recommended that the complete system, including airframe, electronics, armament, and logistics had to be designed from the start[2]. The approach to be utilized was based upon the development of qualitative requirements based upon long term factors such as military strategy, Air Force mission and objectives, probable enemy capability, technological potential, and the development time cycle.

Johnson[2] reports that prior to World War II there was little or no concern with the management of projects. The primary focus of management was the production line or factory. Development of new systems was accomplished in the traditional line organization. During World War II and the years leading up to it, several large-scale systems were developed in a project environment, including the German V-1 and V-2 missiles at Peenemunde, and the U.S. atomic bomb.

The U.S. Army Corps of Engineers was given the responsibility to develop the atomic bomb[5, 6]. Leslie Groves, then deputy chief of construction for the Corps of Engineers, was assigned to head the Manhattan Engineer District (later known as the Manhattan Project). He had previously been in charge of several large construction projects for the Army including the building of the Pentagon. The construction industry required the planning, organization and conduct of an activity limited in duration to the time required for design and construction of structures such as building, bridges and dams. Groves based his organization of the Manhattan Project on his experience with construction projects and the use of multidisciplinary teams of scientists and engineers. This project was immense in scope and included not only the design and development of the weapons at Los Alamos, but also the facilities at Oak Ridge and Hanford for production of the uranium and plutonium, the modification of the B-29s to carry the weapons, and also the operations of the 509th Composite Bomb Group which delivered the weapons.

In the early 1950s, the Air Force was faced with the task of developing a strategic ballistic missile, and Bernard Schriever was selected to lead the development. Johnson[3] states that Schriever was a key figure due to his exposure to all elements of Systems Management. Through Ivan Getting, who at the time was the Air Force's technical director for the Air Defense Command, he knew of the MIT Rad Lab's approach to design of an anti-aircraft system utilizing System Integration. Through his postwar work as the Air Force scientific liaison, he was familiar with Systems Analysis at RAND, which could be used to develop the requirements for future systems. He also recognized the advantages of Groves approach for a project organization and the use of multidisciplinary teams of engineers and scientists. The Air Force created the Western Development Division located in southern California under the command of Schriever to develop this new weapons system. The Air Force and their contractors would now be required to consider the complete system, including operations and support. Schriever used all of these in the Western Development Division for development of the Thor, Atlas, Titan and Minuteman ICBMs, and other space systems.

Missiles represented a considerably different technology than aircraft, and required different operational and support considerations. In the opinion of Schriever, the airframe contractors did not have the requisite experience to fulfill the role of system integrator. He, therefore, gave the contract to a new company called Ramo/Wooldridge (which later became TRW) to provide Systems Engineering and Technical Direction (SETD) support.

The project approach soon spread across the aerospace industry. Johnson[3] reports that the Martin Company in 1954 was using a project approach, one of the first in industry. Bugos[7] describes the project approach used for the development of the F-4 Phantom fighter at McDonnell Aircraft. In 1955 the U.S. Navy instituted the Special Projects Office to manage missile development. In 1956, this office was given the responsibility for development of the Navy's Polaris Fleet Ballistic Missile[9].

But there is one more ingredient required to flesh out the modern practice of Systems Engineering. Johnson[3] points that engineers found that some failures resulted from the test configuration not matching what was called for in the design documentation. In the hurried approach to fix problems and launch, again, the paperwork was not keeping up with the design fixes. This was especially troublesome for space systems, because once launched, the system was no longer available for comparison with the design documentation. These problems resulted in the adoption of configuration management. The Air Force and others learned from Boeing, who used a change processing system and a "change board" in their contract for assembly and test of the Minuteman ICBM.

With the addition of configuration management in the late 1950s, the formula for successful systems engineering was more or less complete. It consisted of systems analysis (developed from Operations Research) to develop a set of requirements for future systems, system integration to design the system as a whole rather than as a collection of components, and configuration management. These legs rest upon the firm foundation of project management that provides the project environment necessary for the implementation of systems engineering.

There are at least several chapters in the history of systems engineering, which we have not covered here. Johnson[3] and Koppes[8] discuss the important role of the Jet Propulsion Lab (JPL). JPL led the development of the Corporal and Sergeant short-range ballistic missiles for the Army and then the development of planetary spacecraft for NASA. The role of Systems Engineering and the approach used for the Apollo manned lunar landing has not been very well documented. The project approach for development of Polaris, the Navy's Fleet Ballistic missile is presented by Sapolsky[9], but without a discussion of the role of Systems Engineering.

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Commentary

Using The System Approach: It Makes Cents

Jeffrey Eyster, eysterj@indy.navy.mil

Expecting a reporter from "Aviation R Us" magazine, I reflected on how our company won the contract to develop the Revolutionary Helicopter Weapon System for the United States Navy. We were not expected to bid for the work, let alone win the contract. During the post-award briefing, I asked the Navy program manager what aspects of our proposal "sold" the program. I remember that he said, "Your proposal offered to us a clear picture that you understood our mission needs, where we planned to use the weapon system, who was going to use it, and who was going to fix it. Your proposal addressed those sticky issues that will affect the sailor for tens of years. In other words, you provided us with clear evidence that you understood the total system picture and that is what we, the Navy, really wanted." We would not have won the contract without our proposal team's tenacity using the system approach to create the proposal.

Our company began applying the system approach to projects after trying innumerable corporate re-engineering fads to decrease our costs, improve our products, and increase our market share. Ten years ago, our company jumped on the Total Quality Management bandwagon with a flurry. The top managers spent two weeks in Dr. Edward Deming's training course learning TQM. We trained the engineers and manufacturing personnel to collect and analyze process data using Statistical Process Control techniques. We documented how we did things, religiously conducted project reviews, collected and analyzed metrics, and changed processes. We did all this in the name of reducing product costs and increasing quality. Just like my New Year's resolution, the effort quickly peaked and waned with no lasting results.

Soon after, our company jumped on the benchmarking bandwagon; the next management improvement wave to roll in. We benchmarked ourselves against several Malcolm Baldrige National Quality award winning companies, copied what the companies thought made them successful, and implemented suggestions from $2500-a-day management consultants. We held monthly quality circles to get everyone involved in process improvement. The employee suggestion box filled with new ideas on how we could make things better. But, this wave crested and retreated just as quickly as TQM with similar results; a lot of money spent, personnel enthusiasm drained, and no sustained improvement in quality or cost.

We finally realized that adopting new programs or investing in the next management consultant fad was not the answer. The fundamental need for our company to improve quality and decrease cost was very simple — do things smartly. We began to rigorously apply the system approach to develop our products and improve our processes.

The reporter for "Aviation R Us" magazine arrives and we begin the interview. "I appreciate your seeing me for the interview," said the reporter. "We want to share the story with our readers of how you successfully designed the Revolutionary Helicopter Weapon System. Can you describe how your company won this Navy contract?"

"Our company was beginning an aggressive campaign to expand our workload. The strategy we employed included responding to proposals for work that we typically did not compete for. We decided to bid for the Revolutionary Helicopter Weapon System program and assembled a proposal response team. The proposal team used the system approach to understand what the Navy really needed the Revolutionary Helicopter Weapon System to do, how the sailors flying the weapon system would use it, and how the Navy would support the weapon system for the next 25 years. The Navy program manager told us that our proposal showed the Navy we understood the total system picture and could provide them with the Revolutionary Helicopter Weapon System they needed."

"Didn't the Navy define what they needed and how they were going to use it?" asked the reporter.

"Certainly the Navy documented key requirements for the Revolutionary Helicopter Weapon System, but there were gaps that needed more detail which is not unusual. As an example, most of the specification addressed a couple of scenarios that had the system working correctly but it did not address what to do if the system did not work in these scenarios. A lot of thought must be given to how the system should behave if something goes wrong. Also, the design team developed other scenarios of how the system could be used that was not described in the specification."

"How did you validate the scenarios," the reporter asked, "and determine the requirements covered all the failure modes?"

"After the contract was awarded, we worked together with the Navy to develop realistic mission scenarios and explored the potential failures or degradation which could affect the mission success. We gathered information from our systems engineers, with their understanding of system performance and limitations, and the end users, with their understanding how they would use the system to do their jobs. It took about three months to flush out the critical requirements and description of system behavior. We then held a System Requirements Review to establish the requirements baseline prior to performing detailed functional analysis of system behavior and developing design solutions."

The idea of doing the detailed functional analysis certainly brought back memories of long days of arguing when to begin built-in test, how to initialize the data for the weapon system, and what bypass functions were necessary to counter the potential failure conditions. I then described how we did the functional analysis to the reporter. "Our design team had many difficult and tumultuous discussions while doing the functional analysis, but we eventually defined what we wanted the system to do during each of the validated scenarios and faults. We did have to be diligent to describe what we wanted the system to do, and avoid answering the question with a specific design solution. We wanted to keep the design solution space free of unnecessary constraints."

"What's the importance of avoiding a design solution? Didn't you just delay the inevitable design decisions?" asked the reporter.

"Based upon my experience, I believe that if you don't follow the system design process and immediately begin selecting system components without really understanding what the system has to do, three things will occur. First, you will select components that will perform a lot of the things the system must do, but will miss some things that are important to the user and get some characteristics that will annoy the user. Second, selecting the components too early will cause the detail design team to spend a lot of money doing the analysis of what each system component must do and a battle will erupt over what is done in hardware or software. Lastly, you will do the functional analysis and system behavior design during either the detail design phase or during testing, but at higher cost. Just like the oil filter commercial where the salesman asks the customer if he wants the filter replaced during an oil change; you can pay me now, or pay me later, but you will pay."

The reporter asked, "What special things did you do to keep your team focused, to solve the typical design issues, and to meet your cost, schedule, and performance goals?"

"The project team remained enthusiastic and dedicated to completing the Revolutionary Helicopter Weapon System. They believed in the need for the weapon system and wanted to make a good product for the sailors. The only special things we did to maintain the enthusiasm were to continually communicate our goals, listen to each other's issues, and take decisive action to fix problems. We did not wait for a design review, completion of a test, or a manager to call a meeting to fix a problem. Each team member took what action they thought would fix the problem and we, the management, accepted their action. A couple of times, the action induced another problem, but the team members quickly took additional action to resolving it. The communication was three-way as opposed to two-way. Two-way communication requires one party to talk and the other party to think of a response. Three-way communication requires one party to talk and the other party to listen—really listen—and think before responding. By listening to each other, we took the time to truly understand the problem or issue, and then implemented the best possible solutions."

"Meeting our cost, schedule, and performance goals was relatively easy because we communicated the goals every day. Each decision, problem fix, or test had to be analyzed for impact to the goals. We certainly had people collecting metrics on cost, schedule, and performance progress and creating graphs and charts. But it was the whole team who analyzed the risks to meeting the goals and suggesting ways we can get back on track or improve our progress to achieve them. We did not invent new methods, create new tools, hire management consultants, or add management layers to keep us on track. Tools and management are poor excuses for not doing things right. These things are only a Band-Aid to prevent losing a pint of blood every 15 minutes. If you don't stop the bleeding, you'll still bleed to death."

The reporter asked one final question, "Other than the people, what do you think made the Revolutionary Helicopter Weapon System team successful?"

As quickly as the reporter asked the question, I responded, "Without a doubt, our belief that there is only one way to do a job; the right way, the system way. Our company followed the management consultants with their ideas for improving market share, improving quality, decreasing costs, and improving profits. We adopted Total Quality Management, benchmarked ourselves against the Motorolas and Texas Instruments, documented processes for everything we did, held quality circles, and, basically, attempted nearly every management fad. We did this until we woke up and smelled the coffee. Who knows our people, our organization, our business, our customers, our capabilities, and our limitations better than us? We realized that we had all the talent and resources necessary to remake ourselves."

"We began to think of ourselves as a system, each component working somewhat independently, but in tandem towards a common goal. We taught ourselves how to think outside our comfort zone, and how we and our products interact with other organizations and systems. The systems approach requires exploring the external system interactions to determine the constraints and boundaries for the system. You then derive the system behavior, which meets the customer's performance objectives within these constraints and boundaries. The system design options are devised and analyzed to determine which one best meets the program cost, schedule, and performance objectives and poses the least technical risk. The detailed design, manufacturing, and testing phases complete the product design process. If we did not take the system approach during each product design phase, the team members would make assumptions about the system boundaries, design constraints, system functionality, and design solutions. And these assumptions would probably not be either consistent or correct."

"The system approach brings order to the design process. It requires the design team to think before making design decisions. A system engineering cliché that I espouse is that all the mistakes in the design are made on the first day. The system approach minimizes the number of mistakes on the first day and reduces the impact of the mistakes. Applying our technical talent to solving the design problem before haphazardly building a product is the right thing to do. If you think about it, the system approach just makes cents."

A Case for Systems Engineering Capability Maturity as Selection Criteria

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I am well aware that systems engineering capability maturity models are supposed to be used for process improvement only. This is probably a reasonable position for a sponsoring organization to avoid potential liabilities from the use of its product for selecting (or not selecting) contractors. Also, it would be great if the benefits to be derived from improving systems engineering capability were so compelling and obvious as to fuel vigorous programs within government and industry. However, it is my opinion that some form of systems engineering capability maturity evaluation should be used as criteria for contractor selection. The absence of this type of motivation will disadvantage systems engineering process improvement activities compared to other disciplines in the competition for resources.

My opinion is based on the obvious investments that have been made by many organizations in recent years in attaining certified achievements in software development and quality assurance. Many procurement activities use the Software Engineering Institute's (SEI) CMM accreditation and/or International Standards Organization's (ISO) 9000 certification as selection criteria. However, systems engineering capability maturity is much less frequently used to select contractors. Organizations must dedicate resources to achieving and maintaining proven software development and quality assurance prowess in order to obtain new business. As a consequence, systems engineering process improvement initiatives are at a disadvantage in competing for managerial attention and investments. This situation is likely to continue until systems engineering capability maturity is also used as a selection criteria in procurements.

The process for achieving this goal will involve both agreement on a form of certification and the education of procurement officials. (A recently retired CIO of a major department of the federal government told me that he did not know there was a systems engineering equivalent of the software CMM.) It seems reasonable to use capability maturity-level evaluations (based on EIA 731) to distinguish organizational capabilities for selecting contractors. However, if capability maturity models are not used for this purpose, then some other form of systems engineering certification should be created and endorsed by INCOSE.

Research on Extending the Use of Systems Insights to Organizations

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Abstract. INCOSE has been the primary force in the development of the science and art of systems architecting. Its science equates to the applied science of engineering, much as the science of civil architecting does to civil engineering. Its art has been developed, through the use of insights (or heuristics), metaphors and models, to treating unprecedented engineering problems for which its applied science— with its built-in need for replicable measurements—is impractical if not impossible. This article reports on the extension of the art of systems architecting to organizational problems such as conceptualizing, team formation, downsizing, reorganization, merging, and divestiture. Applicable cases are indicated in fields as diverse as space exploration and real estate development.

The Motivations of the Research

Systems architects and engineers (SA&E) are well familiar with the basic principle that the elements of system must "fit" each other in order to create a useful "system" result. Less appreciated is the "fit" that must also exist between a product line and the organization that supports it. Organizations are, after all, systems themselves, with structure, connections, constraints, purposes and so on, and therefore should be "structurable." For better or worse, however, organizational problems are almost never replicable or measureable, hence not susceptible to the tools and techniques of applied science. Research was therefore begun to determine the applicability of the insights, metaphors, and models of systems architecting to such problems.

Organizational problems have recently reached the survival level, especially for excellent organizations facing the unknowns and uncertainties of global change. Global transportation, global communications, and global finance have upset the relative stability of the last 50 years. Excellent organizations, both private and government, are finding that being excellent in one domain is no guarantee of excellence, much less success, in others. That much is obvious. What is not readily obvious is exactly what strengths turn into weaknesses, and which long-held assumptions and policies must be radically changed if the organizations are to survive. Research has now identified many of them.

The Use of Insights

It is misleading, if not unethical, to claim that assertions and opinions are workable insights; therefore, a set of criteria were established and the resultant insights were opened to challenge by experienced and employed systems engineers. Four of the most representative, widely accepted, and utilized were:

- Never assume that the original statement of the problem is the best one or even the right one.
- Simplify. Simplify. Simplify.
- Politics, not technology, sets the limits of what technology is allowed to achieve.
- Both success and failure are in the eyes of the beholder—and there are many beholders.

More than 120 insights have been organized corresponding to the interests of organizational architects, including purpose, success/failure, competition, constraints/rules, design, innovating, interfacing, test/diagnosis, and redesign/reorganization.

The Use of Metaphors

Metaphors are used to educate newcomers to a new field or system by choosing an analogous example with enough similarities to the new system that the latter's capabilities can be presumed from the formers. A familiar example is the desktop metaphor for personal computers. The risks for so doing are examined, particularly of system capabilities, beyond those of the metaphor.

Collateral Impacts

Research on insights has uncovered several ideas worth extending. These include the substitution of "stakeholders" for "stockholders" in organizational decision making, particularly for mergers, divestitures and downsizing. Stakeholders include stockholders as only one group; others are the members of the organization from entry level to top executive, the media, Congress, etc.

A second idea is the rapid advance in software such that it is now determining what hardware should be used, rather than the reverse. The impact on how organizations should be structured can be dramatic.

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Eberhardt Rechtin, *is President-emeritus of The Aerospace Corporation, and Professor-emeritus of The University of Southern California.*

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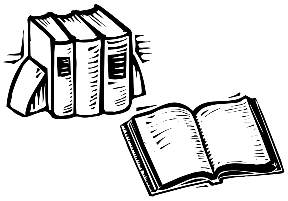

Book Reviews

Managing Risk : Methods For Software Systems Development

By Elaine Hall, published by Addison Wesley Longman Inc., 1998
400 pages, hardcover $54.95, ISBN 0.201.25592.8

reviewed by Dr. David Hillson, Manager of Consultancy, PMP Services Limited, DHillson@pmp.uk.com

Many books claim to be the definitive guide to their subject area, but few live up to the claims of the publisher's blurb. The problem is frequently that although the authors may be experts in their particular area, depth and breadth are often mutually exclusive.

This book avoids the trap by defining its scope very carefully—this is risk management for software development projects. The author is well qualified for the task, with risk-related experience as an academic, an industrial practitioner, and an independent consultant. Elaine Hall is currently chair of the Risk Management Working Group for INCOSE, ensuring that she remains both informed and influential in the field. Her approach to software risk management is therefore important to a wide audience of her peers and colleagues in the software industry, but they are also relevant to the wider risk community. The book also has the endorsement of the prestigious Software Engineering Institute (SEI), adding credibility in the software development world.

Dr. Hall's book is comprehensive and complete, starting from first principles, and developing a clear framework for risk management, before moving on to detail a risk process. Later sections cover infrastructure and implementation issues, finishing with case studies to illustrate risk management in action.

The introductory section has some interesting new concepts, including a development of the Deming Plan-Do-Check-Act cycle into six essential disciplines, then leading to a neat left/right-brain model for risk awareness. The "P2I2 Success Formula" (People, Process, Infrastructure and Implementation) nicely summarizes the areas to be addressed when considering risk management, and a Risk Management Map provides a framework for benchmarking organizational risk management capability.

The section detailing the risk process (identify, analyze, plan, track, resolve) is thorough, but the presentation may be too complex, with each stage being described in terms of inputs, process and outputs. The use of three-level paragraph numbering (e.g. 5.4.3) tends to hinder the reader, with the structure threatening to obscure the message. Nonetheless, the content is good and each stage is clearly described.

Organizations wishing to introduce risk processes will find the sections on infrastructure and implementation of value, whereas the risk practitioner might see these as sections to be skipped. There are however elements of interest here for all, including the need for agreed policy, training, setting risk goals, and auditing process effectiveness.

A book on software risk management might not seem to be essential reading for all those interested in systems engineering or risk management. But this one might be an exception, as it contains so much of general interest. Elaine Hall is to be congratulated on producing a book which captures so many of the important issues in risk management, and which addresses them clearly.
I am not exclusively involved in software development projects, but I expect to return regularly to *Managing Risk* as a valuable reference work. Other risk practitioners within and outside the software industry will probably do the same.

Managing the Risks of Organizational Accidents

James Reason, Ashgate Publishing Limited, 1997

The Texas City Disaster, 1947

Hugh W. Stephens, University of Texas Press, 1997

The above two books, both dealing with organizational safety, are reviewed by Scott Jackson, Sncjxn@aol.com

To call James Reason's *Managing the Risks of Organizational Accidents* an important book would be an understatement, especially to those interested in getting to the root cause of major disasters, such as Challenger, Chernobyl, or Piper Alpha (the North Sea oil platform). This work also has significance for the systems engineer because it looks at the system in the broadest terms, namely, at the organizational level and not just the product. It culminates with a chapter called "Engineering [read systems engineering] a Safety Culture."

Reason begins by destroying the myth of "human error." It's not that individuals don't play a part in major accidents; it's that individual errors are one contributor in a series of problems that are *organizational* in nature. These organizational factors are called latent errors. Latent errors are the result of conditions, such as "poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls in training, and less than adequate tooling." Reason places these factors in five categories: safety-specific factors, management factors, technical factors, procedural factors, and training.

Organizations, he says, do a good job of controlling personal injury accidents, but are not always successful at identifying and controlling the causes of major catastrophes. Reason's work is totally in agreement with Elizabeth Paté-Cornell's earlier analysis, "Organizational Aspects of Engineering System Safety: The Case of Offshore Platforms," *Science* 250, 1990, pp. 1210-16.

Can a safe culture be engineered? Absolutely, says Reason. He dismisses the idea that safety is just a matter of indoctrination. And like a good systems engineer (although he is a psychologist), he lays down a set of requirements for this system (the culture):

- The first requirement is that the culture must be *informed*. This means that there must be a "safety information system that collects, analyzes, and disseminates information from incidents and near-misses as well as from proactive checks on the system's vital signs."
- The culture must be a *reporting* culture "in which people are prepared to report their errors and near-misses."
- The culture must be a *just* culture "in which people are encouraged, even rewarded, for providing essential safety-related information."
- The culture must be *flexible*. This means that control is passed on to experts on the spot, rather than relying on a rigid set of hierarchical rules.

Reason shows how these requirements address the latent conditions and gives many examples of how they can and have been met in many organizations. As for identifying who the organizational systems engineer he only says that it is a "board level" responsibility. On the other hand, if these requirements can be implemented, thousands of lives, and billions of dollars, may be saved. And we will have James Reason to thank.

Although James Reason does not mention the Texas City disaster, the findings of Hugh Stephens in *The Texas City Disaster, 1947* are in complete agreement with Reason's work. In Texas City, approximately 600 people were killed when a French ship, the *Grandcamp,* loaded with ammonium nitrate fertilizer (like Oklahoma City) exploded. Although the cause was never established, it is believed that a cigarette ignited the fire that resulted in the blast.

Although this book does not address the broader issue of organizational safety, it does provide an excellent example, which fully supports Reason's thesis. Like Reason, Stephens lays the blame on three factors, all organizational. First, the Coast Guard, who had the responsibility for controlling explosive materials that pass through ports, had no procedures for checking all ships. Secondly, the Port Authority did not enforce safety rules, such as smoking. Finally, the French captain attempted to snuff out the fire by ordering the hatches closed. This misguided action increased rather than decreased the likelihood of an explosion. Thus, like *Challenger,* Chernobyl, and *Piper Alpha,* the victims of the Texas City disaster lost their lives to organizational factors.

Scott Jackson *is the author of Systems Engineering for Commercial Aircraft and is a survivor of the Texas City disaster.*

Working with Emotional Intelligence

Daniel Goleman, PhD.
Bantam Books 1998

Reviewed by Jack Ring, jring@amug.org

This book is a follow-on to *Emotional Intelligence* which showed that our ability to get things done is more influenced by the way we manage our emotions than by our intellectual ability, especially in non-solitary tasks. Emotional Intelligence does not mean giving free rein to feelings. It means managing feelings so they are expressed appropriately. Ideally, feelings should let everyone work together toward common goals. Also, Emotional Intelligence does not mean "being nice" all the time. Rather it means the ability to fit your cognition and behavior to the situation. Occasionally, that means bluntly confronting someone with a truth that they may be avoiding (such as the risks of "Groupthink" or the opposite, "Spreadthink").

Unlike our IQ which seems to not change much after our teen years, Emotional Intelligence can be learned and improved our whole life through. This book focuses on the outcomes of emotional intelligence in a variety of workplace situations. It shows how an EQ score relates to such outcomes as Security, Earnings and Output volume and quality in legal, sales, software engineering, and other domains.

One example: physicians who fail to show empathy to patients are far more likely to get sued, according to a 1997 study in the *Journal of the American Medical Association*. And, the time needed to exhibit such empathy is only three minutes.

Another example that is related to SE work is the findings regarding computer programmers. Those scoring in the top 1% of EQ produced programs that were about 13 times more effective than the average. Those in the top 10% of EQ produced about 3 times better than the average.

According to Dr. Goleman, optimism may be the single greatest characteristic of successful people, especially in crisis situations.

His list of skills for success includes self-awareness, self-regulation, motivation, empathy, and social skills. The last, social skills, includes: influencing, communicating, leadership, change catalyst, conflict management, building bonds, collaboration, and teaming (creating group synergy in pursuing collective goals).

Although many engineers have a high regard for rational thought and third-person communication style, most great inventions, championships and breakthroughs are clearly dependent on EQ. Those aspiring to be world-class SE practitioners would do well to read this book.

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INCOSE '99 Update

Peter Robson, Symposium General Chair, peter.robson@baedsl.co.uk, peter@robsonpg.demon.co.uk

As I write this, I have just heaved a sigh of relief that the INCOSE '99 brochure has been delivered to the printers. When you read this, I trust that you will have received and avidly perused your brochure to see exactly what is on offer in Brighton from June 6-11. I think you will agree that we have a full, varied and indeed exciting program lined up for you. Moreover, as well as the excitement (and even the fun), this program should really help you develop your competence as a systems engineering professional.

I will not repeat what you can already read in the brochure, but I would like to stress that June in Brighton will be an occasion that acknowledges that INCOSE is now a truly international organization. I'm sure you will want to be there to share in this important event.

Perhaps you've already noticed that we have had to change the dates on our logo—not because we accidentally got them wrong, but because we have had to extend the program to make way for the range of items that have been offered by enthusiastic authors, tutorial providers and panelists. As I said in the closing plenary at the International Workshop in Mesa last January, TGIF ("Thank God It's Friday!") cannot apply until mid-afternoon on the last day! And for the Brits, neither can POETS! (For the North American uninitiated that stands for "Push Off Early Tomorrow's Saturday!") Friday is T&TT day instead (Tutorials and Technical Tours).

With all this increased content, it's not surprising that the brochure is bigger than usual or that it took us longer to produce than we had planned. We hope you are making good use of the web site at http://www.incose.org.uk/incose99 to keep aware of how the symposium is developing in these months leading up to June. More information will appearing on the web site week by week, all of it aimed at making the event more accessible and hence enjoyable for all the delegates.

Professional Conference Management Inc., INCOSE's symposium services provider, have tried hard to provide support for delegates, with contracts with five hotels, the appointment of a U.S. travel agency, and special air fares from North America. There are plenty of opportunities to make it a memorable visit to the U.K. before, during, and after the Symposium. All you need to do is come!

Actually, there is more you can do to help INCOSE make the most of the Brighton opportunity for strategic growth. Spread the message for us in both your own organization and in those other organizations with whom you are in contact. We have an attractive flyer that can be used for basic publicity. If you can use this marketing flyer, please contact Cass Jones at PCMI (pcminc@pcmisandiego.com) if you are in North America, and John Mead (jdmead.a0030182@infotrade.co.uk) if you in Europe or the Rest of the World.

'Brighton' your
Systems Engineering in '99!
See you there!

The Word on the Street…

Ian Sedgley, ian.sedgley@bae.co.uk

...**IS CONFUSING.** Not for the transcontinental nomads and worldly wise polyglots of course; they're comfortable in Europe, America, east of Suez, and west of Panama. But for some of us less sophisticated engineers, Brighton could be a different kettle of bouillabaisse—if that's the phrase I'm looking for. I was trolling around the Internet when I found http://pages.prodigy.com/NY/NYC/britspk/main.html, a site dedicated to the vagaries of the different English languages spoken either side of the Atlantic, and therefore probably well worth a visit before June.

For example, if I tell you that I'm sitting here on my bum absentmindedly twanging my suspenders in search of inspiration, one side of the water will wonder what the homeless person did to merit such treatment while the other will wonder why I wear ladies' lingerie. It gets worse. Let's look at travel. Ignoring the British foible of driving on the left, and therefore coming from a totally unexpected direction when strangers step off that sidewalk, which the Brits call a pavement, in Britain slower moving vehicles are instructed to keep to the inside lane. Seems sensible huh? Probably not so in America where that lane is the one nearest the centre (or indeed, center) of the freeway. Natives will also claim that there are no semi's on Britain's roads. There are plenty of artic(ulated) lorries, but generally what the Brits do with a semi is live in it! To them it's one of a pair of adjoining houses. They also find walking through a subway from A to B relatively stress free probably because they're unlikely to come face to face with a speeding train unless they try it in The Underground.

If you're from Stateside and becoming concerned, take a break—chill out, relax, set a spell, an' cool your saddle; drop by an Off Licence, make that a liquor store, and buy some refreshing cider. Why would you need a liquor store? Brit cider is an alcoholic apple drink that's why. If you overlook that small point in all the excitement and find yourself needing the Men's or Ladies' room, a Pharmacy or ultimately, your bedroom on the fifth floor try asking for the Gents' or Ladies', a Chemist's (shop), and the fourth floor, respectively.

That last item is worth a short explanation. In England they have a quaint tradition of calling the street level the ground floor and the one above it the first floor. Confusing or what? Though it would explain why coming down in the lift or, if you prefer, elevator can be such an exciting experience. You're now quite clear where you're headed when you hit the button marked '1'. But 'M'? That will bring you to the Mezzanine—a sort of mystical land between the first and ground. 'G' will get you the ground, or do I mean the first?, and personally I NEVER touch the one marked 'B'.

After the item in the Winter edition of ***INSIGHT*** I would like to answer some correspondence by pointing out that if you're coming to Brighton you are travelling to England *and* to Great Britain *and* to the United Kingdom. Stand by for the definitive explanation. The Kingdoms of England and Scotland and the Principality of Wales make up Great Britain. Great Britain and the Province of Northern Ireland form the United Kingdom. See? It's all quite simple really.

How will you know when you're there? You're getting close when the seasoned air travellers begin to smile again. It's a reflex action on nearing a landing strip after six hours over water. And you'll know you're in the right place when you hail a cab, whip open the door, leap in and find yourself on the driver's lap. Don't feel too embarrassed, he's quite used to it. And finally, just in case anyone still wonders what the Brits call bums and suspenders, the words are vagrants and braces. I know, I know, don't tell me. I saw those pictures of Chelsea Clinton.

Everything should now be crystal clear. No need to thank me. You're truly welcome and y'all have a nice day now, y'hear.

INCOSE '99 Exhibits Chair has new Email

There has been a change of e-mail for Jane Smith, the INCOSE '99 Exhibits Chair. Jane has moved to Quintec Systems Consultancy, Bristol, U.K. Her e-mail is now jane_smith@quintec.com

In case of any further e-mail address changes, please check the INCOSE '99 web site at http://www.incose.org.uk.

A Taxing Question — What is VAT?

Cecilia Haskins, cha@bdc.no

SALES OR USE TAX. A 17.5% value-added tax (VAT) is levied on most purchases, including hotels and restaurant meals. Non-British passport holders residing outside the United Kingdom may reclaim VAT on goods purchased in London by using Customs Form 407 (some shops keep these forms handy), to be completed and presented to the VAT Enquiries Office at the airport before departure. Shops set their own minimum purchases (usually around £35) for you to qualify for a VAT refund. Certain stores will actually take care of the VAT paperwork for you. Ask first.

At the airport, take your forms to the Tax-Free Cash Refund Desk for reimbursement. For information about the VAT refund process, call Foreign Exchange Tax-Free Shopping, 0800-829-373.

Value Added Tax

The British sales tax (VAT, Value Added Tax) is 17.5%. The tax is almost always included in quoted prices in shops, hotels, and restaurants. You can get a VAT refund by either the Retail Export or the more cumbersome Direct Export method. Most large stores provide these services, but only if you request them, and will handle the paperwork. For the Retail Export method, you must ask the store for Form VAT 407 (you must have identification — passports are best), to be given to customs at your last port of departure. (Lines at major airports can be long, so allow plenty of time.) The refund will be forwarded to you in about eight weeks, minus a small service charge, either in the form of a credit to your charge card or as a British check, which American banks usually charge you to convert. With the Direct Export method, the goods go directly to your home; you must have a Form VAT 407 certified by customs, police, or a notary public when you get home and then sent back to the store, which will refund your money. For inquiries, call the local Customs & Excise office listed in the telephone directory.

For more information and forms, visit these Web sites:

- Britain in the USA: VAT Refunds for Overseas Visitors, http://205.136.244.3/bis/fsheets/28.HTM
- Britain in the USA: VAT Refunds on Business Expenses, http://205.136.244.3/bis/fsheets/23.htm
- Customs & Excise: Information for the Public, http://www.hmce.gov.uk/public/regions/
- Euro VAT Refund, http://www.scan-lan.com/evr/
- European value added tax (vat) reclaim with AUTOVAT refund software, http://www.corporatevat.com/

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Systems Engineering: The Journal of The International Council on Systems Engineering

Call for Papers

The *Systems Engineering* journal is intended to be a primary source of multidisciplinary information for the system engineering and management of products and services, and processes of all types. System engineering activities involve the technologies and system management approaches needed for:

- definition of systems, including identification of user requirements and technological specifications;
- development of systems, including conceptual architectures, tradeoff of design concepts, configuration management during system development, integration of new systems with legacy systems, integrated product and process development; and
- deployment of systems, including operational test and evaluation, maintenance over an extended lifecycle, and reengineering.

The *Systems Engineering* journal is the archival journal of, and exists to serve the following objectives of, the International Council on Systems Engineering (INCOSE).

- To provide a focal point for dissemination of systems engineering knowledge.
- To promote collaboration in systems engineering education and research.
- To encourage and assure establishment of professional standards for integrity in the practice of systems engineering.
- To improve the professional status of all those engaged in the practice of systems engineering.
- To encourage governmental and industrial support for research and educational programs that will improve the systems engineering process and its practice.

The Journal supports these goals by providing a continuing, respected publication of peer-reviewed results from research and development in the area of systems engineering. Systems engineering is defined broadly in this context as an interdisciplinary approach and means to enable the realization of successful systems that are of high quality, cost-effective, and trustworthy in meeting customer requirements.

The *Systems Engineering* journal is dedicated to all aspects of the engineering of systems: technical, management, economic, and social. It focuses on the life cycle processes needed to create trustworthy and high quality systems. It will also emphasize the systems management efforts needed to define, develop, and deploy trustworthy and high quality processes for the production of systems. Within this, *Systems Engineering* is especially concerned with evaluation of the efficiency and effectiveness of systems management, technical direction, and integration of systems. *Systems Engineering* is also very concerned with the engineering of systems that support sustainable development. Modern systems, including both products and services, are often very knowledge intensive, and are found in both the public and private sectors. The Journal emphasizes strategic and program management of these, and the information and knowledge base for knowledge principles, knowledge practices, and knowledge perspectives for the engineering of systems. Definitive case studies involving systems engineering practice are especially welcome.

The Journal is a primary source of information for the systems engineering of products and services that are generally large in scale, scope, and complexity. *Systems Engineering* will be especially concerned with process or product line related efforts needed to produce products that are trustworthy and of high quality, and which are cost effective in meeting user needs. A major component of this is system cost and operational effectiveness determination, and the development of processes that assure products that are cost effective. This requires the integration of a number of engineering disciplines necessary for the definition, development, and deployment of complex systems. It also requires attention to the lifecycle process used to produce systems, and the integration of systems, including legacy systems, at various architectural levels. In addition, appropriate systems management of information and knowledge across technologies, organizations, and environments is also needed to insure a sustainable world.

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Editorial selection of works for publication will be made based on content, without regard to the stature of the authors. Selections will include a wide variety of international works, recognizing and supporting the essential breadth and universality of the field. Final selection of papers for publication, and the form of publication, shall rest with the Editor.

Submission of quality papers for review is strongly encouraged. The review process is estimated to take three to five months. Five copies of your manuscript should be submitted for review purposes to:

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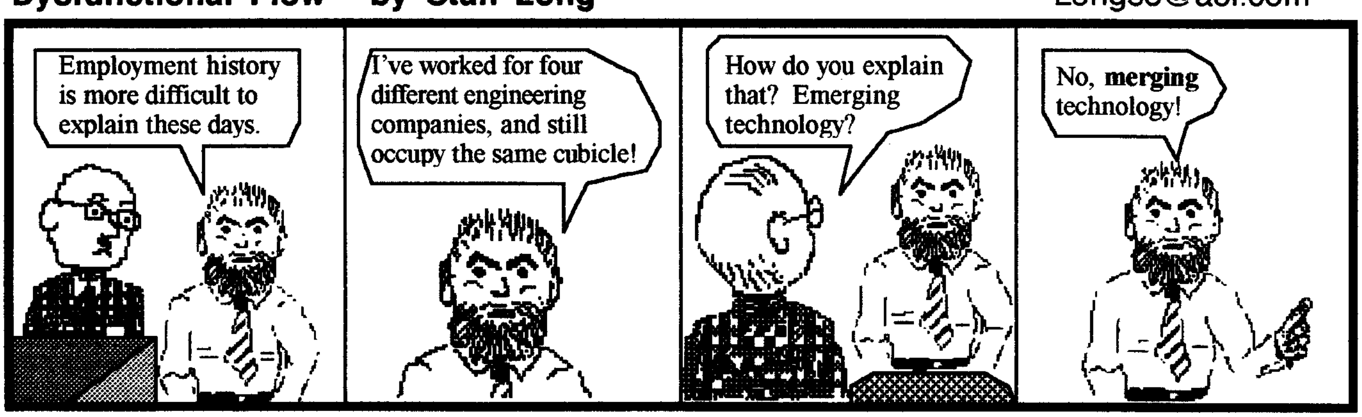
Dysfunctional Flow - by Stan Long Longse@aol.com



Do you have ideas for Stan's next cartoon? Contact him at longse@aol.com

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